



## Forest Service

**Northeastern Forest  
Experiment Station**



# RESEARCH ATTAINMENT REPORT

## FISCAL YEAR 1996



## Abstract

This report contains information on research attainment during fiscal year 1996 at the Northeastern Forest Experiment Station of the USDA Forest Service. Data presented include the funding and staffing for each problem, a narrative summary of the attainment in each problem, and a bibliography of all publications resulting from this research.

KEYWORDS: Research, attainment, research management

# **Research Attainment Report**

## **Fiscal Year 1996**

United States Department of Agriculture  
Forest Service  
Northeastern Forest Experiment Station

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## **Preface**

This attainment report serves as one basis on which to evaluate USDA Forest Service research programs and work unit performance. It also provides information required by the Congress, the Department of Agriculture, and the Office of Management and Budget for their use in evaluating Forest Service research progress. This report for the Northeastern Forest Experiment Station will be aggregated with reports from other Forest Experiment stations to prepare a national report on research programs and accomplishments.

The basis for this report is the Research Work Unit Description (RWUD) for each work unit. The RWUD defines each unit's mission and problems to be studied to accomplish that mission. The approach to detailed investigation of each problem is described in a problem analysis. The problem analysis serves as a basis for preparing a series of study plans, each contributing to the problem solution, and ultimately, to accomplishment of the work unit mission.

## **Introduction**

The Research Work Unit Attainment Reports in Part I each begin with a Research Work Unit Summary. This summary is in the form of a table, listing the problem number and title, the functional account funding the problem, the current level of funding, the current staffing (scientist years) and a tally of the number of publications produced, whether in the work unit, through extramural research, or through cooperative research.

The Research Work Unit Summary is followed by further information for each problem giving the attainments for a single problem. These reports give bibliographic information on each publication resulting from the research on a particular problem, plus a narrative summary of the attainment for that problem.

Part II is a bibliography of all the publications produced as a result of research conducted by the Northeastern Forest Experiment Station in Fiscal Year 1996, listed in alphabetical order by author under the proper functional account.

**Part I: Research Work Unit  
Attainment Reports**

**Northeastern Forest Experiment Station  
Forest Management Research  
Research Work Unit 4103**

**The Role of Environmental Stress on Tree Growth and Development  
Tyree, Melvin T., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Better define and measure state of tree health in order to identify significant stress events	FMR	540	1.7	5		3
2. Towards a better understanding of water-stress physiology: hydraulic sufficiency of stems	FMR	615	2.0	2		1

**Problem 1**

**Better define and measure state of tree health in order to identify significant stress events**  
**FY 96 Research Attainments**

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**Publications****Research Unit**

Schaberg, P.G.; Shane, J.B.; Cali, P.F. 1996. Genetic variation in field photosynthesis and photosynthetic capacity of Vermont red spruce during the cold season. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 35. Abstract.

Schaberg, P.G.; Shane, J.B.; Hawley, G.J.; Strimbeck, G.R.; DeHayes, D.H.; Cali, P.F.; Donnelly, J.R. 1996. Thaw-induced changes in photosynthesis and cold hardiness of red spruce during winter. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 163. Abstract.

Schaberg, P.G. 1996. Cold-season photosynthesis of red spruce in Vermont. Burlington, VT: University of Vermont. 117. Ph.D. dissertation.

Schaberg, P.G.; Shane, J.B.; Hawley, G.J.; Strimbeck, G.R.; DeHayes, D.H.; Cali, P.F. 1996. Physiological changes in red spruce seedlings during a simulated winter thaw. *Tree Physiology*. 16 (6): 567-574.

Zahka, G.A.; Baggett, K.L.; Wong, B.L. 1995. Inoculum potential and other VAM fungi parameters in four sugar maple forests with different levels of stand dieback. *Forest Ecology and Management*. 75: 123-134.

**Cooperative**

D. H. DeHayes; G. R. Strimbeck; P. G. Schaberg; G. J. Hawley. 1996. Membrane calcium depletion: A mechanism for acid precipitation-induced reductions in cold tolerance of red spruce. In: T. H. H. Chen and P. H. Li, comp. Fifth International Plant Cold Hardiness Seminar; August 5-8, 1996; Corvallis, OR. Corvallis, OR: Oregon State University: 176.

Hawley, G.J.; Schaberg, P.G.; DeHayes, D.H.; Strimbeck, G.R.; Cumming, J.R. 1996. Perturbations to membrane calcium: a mechanism for global change-induced cold injury. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 143. Abstract.

Strimbeck, G.R.; Schaberg, P.G.; DeHayes, D.H.; Shane, J.B.; Hawley, G.J. 1995. Midwinter dehardening of montane red spruce during a natural thaw. *Canadian Journal of Forest Research*. 25: 2040-2044.

## Attainment

A comprehensive study of changes in the photosynthetic capacity of red spruce trees during winter showed that trees lose their ability to photosynthesize when temperatures below 0 degrees C persist, but that the capacity for photosynthesis returns rapidly when temperatures moderate. This work (soon to be submitted for publication) was combined with recently published studies of cold tolerance and gas exchange levels of red spruce during winter to form Paul Schaberg's Ph.D. dissertation. An evaluation of the possible role foliar sugars play in regulating photosynthetic and cold hardiness levels was also initiated. A separate survey of changes in physiology associated with environmental nitrogen saturation was conducted in cooperation with Southern Station and University scientists. Results of this survey suggest that chronic N-additions may disrupt the energy relations of red spruce trees (in prep.). Evaluation of changes in the mineral content and mitochondrial respiration of infected and uninfected pine seedlings and associated mycorrhizal fungi to increasing concentrations of heavy metals and acidity have provided information on metal tolerance and tree health. Manuscripts describing the effect of Al and Pb on pine seedlings were recently submitted for publications. Changes in the amount and kinds of sugars present in sugar maple during the leafless period could reflect changes in metabolic activities and have been used to provide information on the state of tree health. This study was expanded to include the characterization of temperature related minor sugar reserves and sugar-like compounds (raffinose and stachyose) synthesized during low temperature. In a separate study the VA mycorrhizal component in the sugar maple stands and its relationship to the maple tree was evaluated as a possible important bioindicator of stand health.

<b>Problem 2</b>	<b>Towards a better understanding of water-stress physiology: hydraulic sufficiency of stems</b> <b>FY 96 Research Attainments</b>
<b>Publications</b>	
<b>Research Unit</b>	<p>Tyree, M.T.; Cochard, H. 1996. Summer and winter embolism in oak: impact on water relations. <i>Annales Des Sciences Forestiere</i>. 53: 173-180.</p> <p>Tyree, Melvin T.; Ewers, Frank W. 1996. Hydraulic architecture of woody tropical plants. In: Mulkey, Stephen S.; Chazdon, Robin L.; Smith, Alan P., comps., eds. <i>Tropical forest plant ecophysiology</i>. New York, NY: Chapman &amp; Hall: 217-243.</p>
<b>Cooperative</b>	<p>Sperry, J.S.; Saliendra, N.Z.; Pockman, W.T.; Cochard, H.; Cruiziat, P.; Davis, S.D. 1996. New evidence for large negative pressures and their measurement by the pressure chamber method. <i>Plant Cell Environment</i>. 19: 427-436.</p> <p>(Ewers, F.W. and Tyree, M.T. are also co-authors.)</p>
<b>Attainment</b>	<p>Studies of hydraulic architecture and vulnerability segmentation in silver maple revealed an unusually high vulnerability to drought-induced xylem dysfunction (xylem embolism) with an unusual segmentation (distribution) of vulnerabilities in that distal portions of shoots are more vulnerable than roots. Silver maple compensates by having an unusually low resistance to water flow in roots and stems, hence it avoids transpiration-induced gradient in xylem pressure that would induce embolism. Our studies also provided quantitative support for the Ohm's law analog for sap flow in plants and hence provided an additional proof of the cohesion theory of sap ascent, which has recently been challenged in Germany. We have also used a community ecology approach to studying comparative vulnerabilities of forest tree species in two tropical sites in Brunei (SE Asia, work financed by a contract from Brunei Shell Oil). Preliminary results indicate that species in Dipterocarp forests are more vulnerable to embolism than species in an adjacent heath forest. This is consistent with differences in edaphic factors; heath forests grow on sandy soils that are better drained and thus more prone to drought events. Studies of hydraulic architecture of trees and shrubs within the Northern Forest Ecosystem have revealed different seasonal patterns of the loss of hydraulic conductivity. These differences may reflect physiological characteristics that enable certain shrubs and small trees to be successful as competitors that limit regeneration and establishment of some commercially desirable trees.</p>

**Northeastern Forest Experiment Station  
Forest Management Research  
Research Work Unit 4104**

**Methods for Measurement, Analysis, and Modeling of Forest Growth and Structure  
Solomon, Dale S., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Traditional methods are inadequate for modeling effects of environmental changes on forest trees	FMR	625	2.0	1		3
2. Present growth predictions inadequate and lack mgmt. strategies, responsive to envir. changes	FMR	175	2.0	3		1

<b>Problem 1</b>	<b>Traditional methods are inadequate for modeling effects of environmental changes on forest trees</b> <b>FY 96 Research Attainments</b>
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**Publications**

<b>Research Unit</b>	Hollinger, D.Y.; Kelliher, F.M.; Schulze, E.-D.; Vygotskaya, N.N.; Varlagin, A.; Milukova, I. 1995. Initial assessment of multi-scale measures of CO <sub>2</sub> and H <sub>2</sub> O flux in the Siberian taiga. <i>Journal of Biogeography</i> . 22: 425-431.
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<b>Cooperative</b>	<p>Arneeth, A.; Kelliher, F.M.; Bauer, G.; Hollinger, D.Y.; Byers, J.N.; Hunt, J.E. 1996. Environmental regulation of xylem sap flow and total conductance of <i>Larix qmelinii</i> trees in eastern Siberia. <i>Tree Physiology</i>. 16: 247-255.</p> <p>Gregoire, Timothy G.; Valentine, Harry T. 1995. A sampling strategy to estimate the area and perimeter of irregularly shaped planar regions. <i>Forest Science</i>. 41 (3): 470-476.</p> <p>Whitehead, D.; Hogan, K.P.; Rogers, G.N.D.; Byers, J.N.; Hunt, J.E.; McSeveny, T.M. 1995. Performance of large open-top chambers for long-term field investigations of tree response to elevated carbon dioxide concentration. <i>Journal of Biogeography</i>. 22: 307-313.</p>
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**Attainment**

The amount of carbon dioxide (CO<sub>2</sub>) in the atmosphere is increasing every year, and these increased levels of CO<sub>2</sub> are known to affect plant growth processes and are generally expected to lead to changes in the climatic system. An investigation of how much CO<sub>2</sub> a central Maine spruce-fir forest removes from the atmosphere as it grows and how environmental factors regulate this forest uptake continued. This collaborative study with researchers from the University of Maine, the Woods Hole Research Center, and Cornell is also tracing where carbon is stored within the forest ecosystem. New measurements this year allow total forest CO<sub>2</sub> exchange to be partitioned into forest floor and canopy components. The site will act as a model for other northern hemisphere boreal forests.

The Pipestem model was linked to a steady-state, carbon-flux model in order to gauge the effects—on stand growth—of weather and other environmental factors. Analyses of the linked model, with parameter values set for *Pinus taeda* L., indicate that (1) the rate of stand growth becomes more sensitive to environmental influences as a stand ages and maintenance respiration increases, and (2) gains in yield should be realized in the next 30 years under the assumption that atmospheric CO<sub>2</sub> concentration will increase by 1.6 ppm per year. Analyses with the atmospheric CO<sub>2</sub> set at 700 ppm indicate faster growth and higher yields with average monthly warming of 0 to 4 degrees C.

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**Problem 2**                      **Present growth predictions inadequate and lack mgmt. strategies, responsive to envir. changes**  
**FY 96 Research Attainments**

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**Publications**

**Research Unit**                      Gove, Jeffrey H.; Linder, Ernst; Tzilkowski, Walter M. 1995. Bimodality of the combined removal and signs-of-activities estimator for sampling closed animal populations. *Environmental and Ecological Statistics*. 3: 65-80.

   Gove, Jeffrey H.; Patil, Ganapati P.; Taillie, Charles. 1996. Diversity measurement and comparison with examples. In: Szaro, Robert C.; Johnson, David W., comps., eds. *Biodiversity in managed landscapes: theory and practice*. New York, NY: Oxford University Press: 157-175.

   Solomon, Dale S.; Leak, William B. 1995. Evaluation of methodology for detecting/predicting migration of forest species. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program*; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 175-182.

**Cooperative**                      Gove, J.H.; Houston, D.R. 1996. Monitoring the growth of American beech affected by beech bark disease in Maine using the Kalman filter. *Environmental and Ecological Statistics*. 3: 167-187.

**Attainment**

Techniques for the measurement and comparison of diversity between communities at a given time and within a community over time have been presented with examples that show how computations are done and comparisons made. Our previous work on combined removal and signs-of-activities wildlife sampling estimators has been extended, providing a new model that accounts for the violation of assumptions with regard to equal catchability of animals. The new estimator takes into consideration the combination of contradictory data involved in combining the likelihoods of the removal and signs-of activities models when the equal catchability assumption is not met, producing unimodel rather than bimodel combined likelihoods.

A dendrochronological study of paired resistant and susceptible American beech trees was reported on describing the long-term effects of beech bark disease complex on two different sites in Maine. Kalman filtering techniques were used to analyze the time series showing the interaction of stand dynamics and the disease complex.

A handbook describing the use and methods of inventorying forest stands has been completed. FIBER and FLEXINV allow resource managers to use these silviculture tools to inventory and simulating forest stands through succession stages and changes in diversity.

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**Northeastern Forest Experiment Station  
Forest Management Research  
Research Work Unit 4151**

**Ecology and Management of Northern Conifer and Associated Ecosystems  
Brissette, John C., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Long-term effects of silvicultural options on habitat diversity, stand structure, and yields	FMR	350	.8	3	1	1
2. Developing information about the ecophysiology of northern conifer seedling establishment	FMR	50	.2	1		

<b>Problem 1</b>	<b>Long-term effects of silvicultural options on habitat diversity, stand structure, and yields</b> <b>FY 96 Research Attainments</b>
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<b>Publications</b>	
<b>Research Unit</b>	<p>Brissette, John C., ed. 1996. Proceedings of the tree shelter conference. Gen. Tech. Rep. NE-221. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 80.</p> <p>Frank, Robert M.; Stone, Timothy L.; Crawford, Hewlette S. 1996. Tree/wildlife diversity responses to silvicultural practices in northern conifers. In: Sustaining forests, sustaining people: proceedings of the 1995 SAF convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 413-414.</p> <p>Kenefic, Laura S.; Nyland, Ralph D. 1996. Structural development and consistency in uneven-aged northern hardwood stands. In: Sustaining forests, sustaining people: proceedings of the 1995 SAF convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 441-442.</p>
<b>Cooperative</b>	Sendak, P.E.; Frank, R.M.; Brissette, J.C. 1996. Financial analysis of northern conifer stands under various silvicultural treatments. In: Sustaining forests, sustaining people: proceedings of the 1995 SAF convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 368-369.
<b>Extramural</b>	Hagan, John M.; VanderHaegen, W. Matthew; McKinley, Peter S. 1996. The early development of forest fragmentation effects on birds. <i>Conservation Biology</i> . 10 (1): 188-202.
<b>Attainment</b>	<p>Continued our long-term silviculture research with completion of seven scheduled inventories and one scheduled diameter-limit harvest in the Compartment Management Study. An additional three inventories and three harvests were conducted in unreplicated Management Intensity Demonstration areas. New research to study carbon content of snags and coarse woody debris was initiated with Northern Global Change Program and University of Maine cooperators. Another new study on the impact of repeated harvesting on genetic diversity of hemlock is underway with University of Vermont cooperators with funding from the Northern Global Change Program. Our long-term study areas were visited by nearly 300 people from professional groups and the public. Notable visitors included a pre-national convention tour by the Silviculture Instructors subgroup of the Society of American Foresters and a delegation of Russian forest managers and scientists. A financial analysis of returns from various harvest operations since the 1950s was completed in cooperation with NE-4154, presented at three professional meetings, and written for journal publication.</p>

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<b>Problem 2</b>	<b>Developing information about the ecophysiology of northern conifer seedling establishment</b>
	<b>FY 96 Research Attainments</b>

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**Publications****Research Unit**

Brissette, John C.; Barnett, James P.; Jones, John P. 1996. Fungicides improve field performance of stored loblolly and longleaf pine seedlings. Southern Journal of Applied Forestry. 20 (1): 5-9.

(Reports on research Brissette conducted in previous assignment.)

**Attainment**

In a study funded by the Northern Global Change Program, NE-4151 and cooperators at the University of Maine and Dartmouth College are investigating the dynamics determining range limits of jack pine and pitch pine in eastern Maine. Dendrochronological, ecological and phenological data have been collected, seeds collected and seedlings produced for growth analysis and cold-hardiness determinations. In another study, a post-doctoral scientist continued to investigate the relationship between red spruce regeneration and forest floor and understory vegetation. Preliminary results of that research have been presented at professional and scientific meetings. Regeneration data from Problem 1 were examined in order to provide a foundation for additional studies under Problem 2. Results of that analysis were presented at professional and scientific meetings and published in an international journal.

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**Northeastern Forest Experiment Station  
Forest Management Research  
Research Work Unit 4152**

**Understanding and Managing Forest Ecosystems of the Allegheny Plateau Region  
Stout, Susan L., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Regeneration and forest renewal	FMR	348	1.3	6		2
2. Stand dynamics and silviculture	FMR	305	1.3	3	2	2
3. Sugar maple decline	FMR	300	1.3	2		2

Problem 1

Regeneration and forest renewal  
FY 96 Research Attainments

Publications

Research Unit

Horsley, S.B. 1996. Interaction of deer density and understory lighting with height of red maple (*Acer rubrum* L.) seedlings in Allegheny hardwood stands. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 48. Abstract.

Horsley, Stephen B.; Ristau, Todd E. 1996. Pin Cherry effects on Allegheny hardwood stand development. I. Short-term impacts. In: Glenn, S., ed. Fifty years of progress: proceedings of the 50th annual meeting of the Northeastern Weed Science Society; 1996 January 2-5; Williamsburg, VA. [Place of publ. unknown]: Northeastern Weed Science Society: 49. Abstract.

Horsley, Stephen B.; Ristau, Todd E. 1996. Pin cherry influences development of Allegheny hardwood stands. Supplement to Bulletin of the Ecological Society of America. 77(3): 203. Abstract.

Ristau, Todd E.; Horsley, Stephen B.; McCormick, Larry H. 1996. Seasonal variations on non-aborescent vascular species diversity in Allegheny hardwoods. Supplement to Bulletin of the Ecological Society of America. 77(3): 376. Abstract.

Stout, S.L.; deCalesta, D.S.; DeMarco, L. 1996. Can silviculture change deer impact? In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 437-438.

Stout, Susan L.; Lawrence, R. 1996. Deer in Allegheny Plateau forests: learning the lessons of scale. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 92-98.

Cooperative

McWilliams, William H.; Stout, Susan L.; Bowersox, Todd W.; McCormick, Larry H. 1995. Adequacy of advance tree-seedling regeneration in Pennsylvania's forests. Northern Journal of Applied Forestry. 12 (4): 187-191.

Styer, Jean W.; Carson, C. Walter; Horsley, S. 1996. The impact of white-tailed deer on the seed banks of two second-growth forests in the Allegheny National Forest, Pennsylvania. Supplement to Bulletin of the Ecological Society of America. 77(3): 429. Abstract.

Attainment

Work completed this year examined three different aspects of improving regeneration success and diversity. Scientists developed guidelines for controlling the impact of pin cherry on the development of more commercially valuable and diverse regeneration. Scientists showed that there were strong interactions between deer browsing and lighting effects on red maple height growth; at 10 and 20 deer per square mile, red maple seedlings in uncut stands were strongly responsive to light levels; at 38 and 64 deer per square mile, deer browsing prevented seedlings in high light environments from achieving greater height. But in other work, scientists and collaborators in land management agencies showed that manipulation of the amount of deer forage in the surrounding landscape could reduce the impact of deer on regeneration development.

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**Problem 2**  
**Stand dynamics and silviculture**  
**FY 96 Research Attainments**

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**Publications****Research Unit**

Nowak, Christopher A. 1996. Wood volume increment in thinned, 50- to 55-year-old, mixed-species Allegheny hardwoods. *Canadian Journal of Forest Research*. 26: 819-835.

Ristau, Todd E.; Horsley, Stephen B. 1996. Pin cherry effects on Allegheny hardwood stand development. II. Long-term impacts. In: Glenn, S., ed. *Fifty years of progress: proceedings of the 50th annual meeting of the Northeastern Weed Science Society*; 1996 January 2-5; Williamsburg, VA. [Place of publ. unknown]: Northeastern Weed Science Society: 49. Abstract.

Stout, Susan L. 1995. Overview of ecosystem management and its importance. In: Finley, James C.; Jones, Stephen B., eds. *Ecosystem management: translating concepts to practice*, 1995 Penn State School of Forest Resources issues conference; 1995 March 15-16; State College, PA. State College, PA: The Pennsylvania State University, School of Forest Resources: 1-12.

**Cooperative**

Oswald, Brian P.; Zhang, Lianjun; Green, Thomas H.; Stout, Susan L. 1995. Height-diameter relationships of dominant trees in the mixed upland hardwood forests in north Alabama. In: Edwards, M. Boyd, comp. *Proceedings of the 8th biennial southern silvicultural research conference*; 1994 November 1-3; Auburn, AL. Gen. Tech. Rep. SRS-1. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 596-598.

Zhang, Lianjun; Oswald, Brian P.; Green, Thomas H.; Stout, Susan L. 1995. Relative density measurement and species composition in the mixed upland hardwood forests of north Alabama. In: Edwards, M. Boyd, comp. *Proceedings of the 8th biennial southern silvicultural research conference*; 1994 November 1-3; Auburn, AL. Gen. Tech. Rep. SRS-1. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 467-472.

**Extramural**

McGuinness, B.J.; Steiner, K.C. 1996. A heritage for the 21st century: Pennsylvania's native biological diversity conservation strategy. In: *Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention*; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 410-411.

McGuinness, Barbara J. 1995. A heritage for the 21st century: summary and results of Pennsylvania's biodiversity conservation plan. In: Finley, James C.; Jones, Stephen B., eds. *Ecosystem management: translating concepts to practice*, 1995 Penn State School of Forest Resources issues conference; 1995 March 15-16; State College, PA. State College, PA: The Pennsylvania State University, School of Forest Resources: 51-57.

**Attainment**

A thinning study in 50- to 55-year-old, even-aged, mixed species Allegheny hardwoods produced highly variable merchantable stemwood increment responses. Much of this variation could be explained by pretreatment species composition. Plots with a high proportion of black cherry and little sugar maple showed a decrease in wood volume increment with decreases in relative stand density. Stands with a high proportion of sugar maple and a low proportion of black cherry showed an increase in wood volume increment with decreases in relative density. Adjusted thinning guidelines are being prepared to account for these differences. Scientists at Warren also contributed to our understanding of stand development processes in mixed hardwood stands, including those with high proportions of pin cherry when young. Additional contributions concerned biological diversity, ecosystem management, and professional ethics.

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**Problem 3**  
**Sugar maple decline**  
**FY 96 Research Attainments**

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**Publications****Research Unit**

Stout, S.L.; Nowak, C.A.; Horsley, S.B.; Long, R.P.; White, R.; McWilliams, W. 1996. Forest health on Pennsylvania's Allegheny Plateau. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 435-436.

Stout, Susan L.; Nowak, Christopher A.; Redding, James A.; White, Robert; McWilliams, William. 1995. Allegheny National Forest health. In: Eskew, Lane G., comp. Forest health through silviculture: proceedings of the 1995 national silviculture workshop; 1995 May 8-11; Mescalero, NM. Gen. Tech. Rep. RM-GTR-267. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 79-86.

**Cooperative**

Long, R.P.; Horsley, S.B.; Lilja, P.R. 1996. Nutrient status and sugar maple health: liming effects on growth, vigor, seed crops, regeneration, and foliage chemistry in northcentral Pennsylvania. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 74. Abstract.

McWilliams, William H.; White, Robert; Arner, Stanford L.; Nowak, Christopher A.; Stout, Susan L. 1996. Characteristics of declining forest stands on the Allegheny National Forest. Res. Note NE-360. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9.

**Attainment**

Analysis of aerial photographs and ground survey data from the last decade reveal high levels of mortality affecting about 20,000 to 25,000 acres on the Allegheny National Forest. Within the last decade, the forest has experienced attacks by 3 native and 3 exotic defoliators, 3 droughts, and late frosts and unusual winters. Review of historic study records shows that stands on well-watered sites and those that were thinned prior to the defoliations and droughts were less impacted by the mortality. Results from a 10-year study in which dolomitic limestone was applied to declining sugar maple stands on base-cation poor soils show that addition of lime increased overstory vigor, seed production, and growth. Understory responses reflected the interacting effects of deer, fern, and lime. Analysis of these data also revealed a strong correlation between sugar maple seed crops and summer droughts.

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**Northeastern Forest Experiment Station  
Forest Management Research  
Research Work Unit 4153**

**Quantitative Methods for Modeling Ecosystem Response  
Scott, Charles T., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Integrating models of plant processes with forest and landscape processes	FMR	0	.0			
2. Modeling of oak plant community responses to natural stressors and ecosystem management	FMR	377	2.7	7	7	3
3. Developing ecosystem management practices for aesthetics, biodiversity, habitat and timber	FMR	453	1.6	1		
4. Monitoring subtle responses of forest ecosystems to global climate change and other stressors.	FMR	61	.6			

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<b>Problem 1</b>	<b>Integrating models of plant processes with forest and landscape processes FY 96 Research Attainments</b>
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**Publications**

none

**Attainment**

No progress to report this period. Work on this Problem is largely complete. As progress continues in Problem Area 2, the conceptual model will be revised and refined as necessary.

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**Problem 2**                      **Modeling of oak plant community responses to natural stressors and ecosystem management**  
**FY 96 Research Attainments**

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**Publications**

**Research Unit**

Barrett, Hope R. 1996. Catalog of long-term research conducted within the USDA Forest Service, Northeastern Forest Experiment Station. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service; Northeastern Forest Experiment Station: 226. Abstract.

Iverson, Louis R., and Prasad, Anantha. 1996. Modeling present and potential future individual tree species importance values in the Eastern United States. In: Integration of cultural and natural ecosystems across landscapes: application of the science. 11th annual landscape ecology symposium. 1996 March 26-30; Galveston, TX. Abstract.

Iverson, Louis R.; Prasad, Anantha M.G.; Scott, Charles T. 1996. Preparation of forest inventory and analysis (FIA) and state soil geographic data base (STATSGO) data for global change research in the eastern United States. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 209-214.

Iverson, Louis R.; Scott, Charles T.; Dale, Martin E.; Parasad, Anantha. 1996. Development of an integrated moisture index for predicting species composition. In: Koehl, Michael; Gertner, George Z., eds. Caring for the forest: research in a changing world. Statistics, mathematics and computers. Proceedings of the meeting of IUFRO S4.11.00 XX World Congress; 1995 August 6-12; Tampere, Finland. Birmensdorf, Switzerland: Swiss Federal Institute for Forest, Snow and Landscape Research: 101-116.

Sutherland, Elaine Kennedy; Grassino-Mayer, Henri; Woodhouse, Connie. 1996. The history of fire in a southwestern Virginia *Pinus pungens* stand. In: Fire in ecosystem management: shifting the paradigm from suppression to prescription; 1996 May 7-10; Boise, ID. [Place of publ. unknown]: [Publisher name unknown]. Poster Abstract.

Sutherland, Elaine Kennedy; Hale, Betsy J.; Hix, David M. 1996. Regeneration attributes of tree species in the central hardwoods type. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 215. Abstract.

Sutherland, Elaine Kennedy; Yaussy, Daniel A.; Boerner, Ralph E.J. 1996. Mortality patterns in oak forests along a climatic and acid deposition gradient. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. In: Proceedings, 1995 meetings of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 168. Abstract.

**Cooperative**

Boerner, Ralph E.J.; Sutherland, Elaine Kennedy. 1996. Relative nitrogen mineralization and nitrification potentials in relation to soil chemistry in oak forest soils along a historical deposition gradient. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 167. Abstract.

Mitasova, Helena; Hofierka, Jaroslav; Zlocha, Maros; Iverson, Louis R. 1996. Modelling topographic potential for erosion and deposition using GIS. *International Journal of Geographical Information Systems*. 10 (5): 629-641.

Schwartz, Mark W.; Iverson, Louis R.; and Prasad, Anantha. Projected tree distribution shifts under global climate change in the fragmented Ohio landscape. In: Ecologists/biologists as problem solvers: program and abstracts: part 2. 1996 annual combined meeting of the ESA: 1996 August 10-14; Providence, RI. Supplement to Bulletin of the Ecological Society of America. 77(3): 106. Abstract.

## Extramural

Decker, Kelly L.M.; Fisher, Michael J.; Boerner, Ralph E.J. 1996. Landscape scale and microbial ecology. II. Soil enzyme activity. Supplement to Bulletin of the Ecological Society of America. 77(3): 106. Abstract.

Decker, Kelly L.M.; Fisher, Michael J.; Boerner, Ralph E.J. 1996. Landscape scale and microbial ecology. II. Soil enzyme activity. Ohio Journal of Science. 96(2): A-22. Abstract.

Decker, Kelly L.M.; Morris, Sherri J.; Boerner, Ralph E.J. 1996. Ca:A1 ratio effects on competition between arbuscular mycorrhizal and ectomycorrhizal forest trees. In: 1st international conference on mycorrhizae; 1996 August 4-9; Berkeley, CA. [Place of publ. unknown]: [Publisher name unknown]. Poster Abstract.

Morris, Sherri J.; Brinkman, Jennifer A.; Boerner, Ralph E.J. 1996. Landscape scale and microbial ecology. I. Nitrogen turnover. Supplement to Bulletin of the Ecological Society of America. 77(3): 314. Abstract.

Morris, Sherri J.; Brinkman, Jennifer A.; Boerner, Ralph E.J. 1996. Landscape scale and microbial ecology. I. Nitrogen turnover. Ohio Journal of Science. 96(2): A-22. Abstract.

Schwartz, Mark W. 1996. Assessing the ability of plants to respond to climatic change through distribution shifts. In: Horn, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 184-191.

Stanton, R.C.; Horn, D.J.; Purrington, F.F. 1996. Ground beetles (carabidae) diversity and abundance in mixed-oak forests in southern Ohio. In: Meeting of north central branch of Entomological Society of America; 1996 March 24-27; Omaha, NE. [Place of publ. unknown]: [Publisher name unknown]. Poster Abstract.

## Attainment

In an effort to predict responses to global change, nitrogen turnover rates were investigated at the region, watershed, and topographic scales. While N mineralization and NH<sub>4</sub> pool sizes varied significantly, only at the scale, NO<sub>3</sub>, pool sizes and nitrification varied at all three scales. These results support the hypothesis that ecological processes which depend on a small guild of specialists (such as nitrification by microbes) will vary more in time and space than processes mediated by large, diverse guilds (such as mineralization). Thus, different nutrient cycling processes should be expected to operate at different combinations of scale, and thus must be considered when predicting effects of environmental change on these processes.

A related study of enzyme systems added a fourth scale: microsite differences. These enzyme systems are the result of microbial activity. The enzymes studied and soil organic matter all varied significantly at the regional and watershed scales. Although there were topographic and microsite differences, they were not as strong as for N turnover.

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<b>Problem 3</b>	<b>Developing ecosystem management practices for aesthetics, biodiversity, habitat and timber</b>
	<b>FY 96 Research Attainments</b>

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**Publications**

**Research Unit**      Yaussy, Daniel A.; Sutherland, Elaine Kennedy; Hale, Betsy J. 1996. Rule-based, individual-tree regeneration model for forest simulators. In: Skovsgaard, J.P.; Johannsen, V.K., eds. Modelling regeneration success and early growth of forest stands: proceedings from the IUFRO conference; 1996 June 10-13; Copenhagen, Denmark. Horsholm, Denmark: Danish Forest and Landscape Research Institute: 176-182.

**Attainment**

The regeneration subroutines in many forest growth simulators are ingrowth predictors. Often stems enter the tree list as 2.5 cm in diameter depending on microsite and species characteristics. Any species in the species list is a potential supply of stems, even if it is not present on the plot list.

Our objective has been to develop a mechanistic model of tree regeneration (MOM: Mechanistic Origination Model) that is responsive to widely varying environmental conditions and management practices. We assume that regeneration is disturbance driven. Disturbance is multidimensional and varies in effect and in spatial and temporal scales. Thus, to model regeneration, we need to characterize regeneration traits and simulate disturbance processes.

In the forest simulator we are using, ZELIG 1.0, we are replacing the ingrowth simulator with MOM and adding a set of disturbance algorithms that simulate harvesting, windthrow, and fire. Algorithms for other disturbances will be added later.

The combination of MOM and ZELIG (MOM/Z) will be used initially to predict the migration of tree species due to climate change. MOM may also be incorporated into other growth and yield models, such as NE-TWIGS.

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**Problem 4**                      **Monitoring subtle responses of forest ecosystems to global climate change and other stressors.**  
**FY 96 Research Attainments**

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**Publications**

none

**Attainment**

No published progress to report.

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**Northeastern Forest Experiment Station  
Forest Management Research  
Research Work Unit 4154**

**Ecology and Management of Northern Hardwoods and Associated Ecosystems  
Garrett, Peter W., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Understand and document the structure and dynamics of northern hardwood ecosystems	FMR	330	3.0	11	7	2
2. Better understand the ecological relationships between wildlife habitat and forest management	FMR	330	1.0		2	3
3. Need to preserve undisturbed areas to study natural succession and impacts of global change	FMR	124	.5	1	3	
4. Need to preserve integrity of older plantations to document responses to environmental change	FMR	42	.5			

Problem 1

Understand and document the structure and dynamics of northern hardwood ecosystems  
FY 96 Research Attainments

Publications

Research Unit

Carpenter, Constance A.; Smith, Marie-Louise; Fay, Stephen. 1995. What do ecological unit boundaries mean? The dual role of ecological units in ecosystem analysis: examples from the New England and New York state. In: Thompson, Joyce Elma, comp. Analysis in support of ecosystem management. Analysis workshop III; 1995 April 10-13; Fort Collins, CO. Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Analysis Center: 8-19.

Dennis, Donald F.; Sendak, Paul E. 1996. Stumpage price trends in New England: 1964-1995. In: Brissette, John C., comp. 76th winter meeting of the New England Society of American Foresters; 1996 March 19-21; Lowell, MA. [Place of publ. unknown]: New England Society of American Foresters: 4. Poster Abstract.

Leak, William B. 1996. Long-term structural change in uneven-aged northern hardwoods. *Forest Science*. 42 (2): 160-165.

Leak, William B.; Smith, Marie-Louise. 1996. Sixty years of management and natural disturbance in a New England forested landscape. *Forest Ecology and Management*. 81: 63-73.

Pilgrim, Sid; Falk, Laura; Sperduto, Dan; Desmaris, Ken; Fay, Steve; Leak, William B.; Smith, Marie-Louise; Carpenter, Constance; Publicover, David. 1996. Land type associations of New Hampshire. In: Brissette, John C., comp. 76th winter meeting of the New England Society of American Foresters; 1996 March 19-21; Lowell, MA. [Place of publ. unknown]: New England Society of American Foresters: 19. Poster Abstract.

Sandak, Paul E.; Koelling, Melvin R. 1996. Economics of maple syrup production. In: North American Maple Syrup Producers Manual. Ohio State University Extension Bulletin 856. Columbus, Ohio: Ohio State University: 144-154.

Sendak, Paul E. 1996. Role of economic incentives in conserving wildlife habitat. In: Kohn, Michael; Gertner, George Z., eds. Caring for the forest: research in a changing world. Statistics, mathematics and computers. Proceedings of the meeting of IUFRO XX World Congress; 1995 August 6-12; Tampere, Finland. Birmensdorf, Switzerland: Swiss Federal Institute for Forest, Snow and Landscape Research: 82-83. Abstract.

(Full paper presented at Congress. Abstracts of papers printed in Proceedings.)

Sendak, Paul E.; Frank, Robert M.; Brissette, John C. 1996. Financial analysis of northern conifer stands under various silvicultural treatments. In: Brissette, John C., comp. 76th winter meeting of the New England Society of American Foresters; 1996 March 19-21; Lowell, MA. [Place of publ. unknown]: New England Society of American Foresters: 23. Poster Abstract.

Sendak, Paul E.; Frank, Robert M.; Brissette, John C. 1996. Financial analysis of northern conifer stands under various silvicultural treatments. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 368-369.

Smith, Marie-Louise; Carpenter, Constance. 1996. Application of the USDA Forest Service national hierarchical framework of ecological units at the sub-regional level: the New England-New York example. In: Sims, Richard A.; Corns, Ian G.W.; Klinka, Karel, comps., eds. Global to local: ecological land classification. Dordrecht, The Netherlands: Kluwer Academic Publishers: 187-198.

Tritton, Louise M.; Sendak, Paul E. 1995. Ecological aspects of forest management planning: a northern hardwood forest case study. *Northern Journal of Applied Forestry*. 12 (3): 121-126.

Cooperative

Aber, John D.; Magill, Alison; McNulty, Steven G.; Boone, Richard D.; Nadelhoffer, Knute J.; Hallett, Richard A. 1995. Forest biogeochemistry and primary production altered by nitrogen saturation. *Water, Air and Soil Pollution*. 85: 1665-1670.

Harris, M.M.; Safford, L.O. 1996. Effects of season and four tree species on soluble carbon content in fresh and decomposing litter of temperate forests. *Soil Science*. 161 (2): 130-135.

## Extramural

Aber, John; Magill, Alison; McNulty, Steven; Boone, Richard; Nadelhoffer, Knute; Downs, Morty; Hallett, Richard. 1996. Forest biogeochemistry and primary production altered by nitrogen saturation. Supplement to Bulletin of the Ecological Society of America. 77(3): 2. Abstract.

Anderson, Mark G.; Sneddon, L.A.; Smith, M.L.; Carpenter, C. 1996. Relationships between a geophysical based land classification system. Supplement to Bulletin of the Ecological Society of America. 77(3): 12. Abstract.

Bobola, Michael S.; Eckert, Robert T.; Klein, Anita S.; Stapelfeldt, Karen; Hillenberg, Kimberly A.; Gendreau, Steve B. 1996. Hybridization between *Picea rubens* and *Picea mariana*: differences observed between montane and coastal island populations. Canadian Journal of Forest Research. 26: 444-452.

(Unit provided funds through a Cooperative Agreement.)

Bobola, Michael S.; Eckert, Robert T.; Klein, Anita S.; Stapelfeldt, Karen; Smith, Dirk E.; Guenette, Denis. 1996. Using nuclear and organelle DNA markers to discriminate among *Picea rubens*, *Picea mariana*, and their hybrids. Canadian Journal of Forest Research. 26: 433-443.

(Unit supplied funding through Cooperative Agreement.)

Falk, Laura; Lanier, John; Carpenter, Constance; Leak, William B.; Smith, Marie-Louise; Fay, Steve. 1996. Landscape of New Hampshire. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 383. Abstract.

Keys, James E., Jr.; Carpenter, Constance A.; Hooks, Susan L.; Koenig, Frank G.; McNab, Henry W.; Russell, Water E.; Smith, Marie-Louise. Supplement to Bulletin of the Ecological Society of America. 77(3): 232. Abstract.

Pilgrim, Sid; Falk, Laura; Sperduto, Dan; Desmaris, Ken; Leak, William B.; Smith, Marie-Louise. 1996. Landtype associations of New Hampshire. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 378-379.

## Attainment

Much of the past ecological research has been at the stand level. To meet the ecosystem management requirements, a framework is needed to categorize the ecological capability and characteristics of larger landscapes. Based on the USDA Forest Service National Hierarchical Framework, 17 sections and 58 proposed subsections were mapped for the New England-New York region using a map-overlay approach coupled with a collaborative review progress. These units fulfill the dual role of helping to focus our understanding of natural systems and providing unified direction for management efforts. At the next level below the subsection, landtype associations were mapped for New Hampshire to provide a basis for the State Forest Plan. Sixty years of management and natural disturbance were documented for the Bartlett Experimental Forest based on over 400 cruise plots established in the early 1930's. The findings showed that natural succession is the major factor affecting these forests, emphasizing the resilience of northern hardwood types to timber management, windthrow, and disease. A similar theme was developed from a stand-level study of changes in diameter distribution over a 35-year period following a range of diameter-limit and single-tree selection cutting. All ten stands in the study produced well-developed, sustainable diameter distributions over time, ranging in shape from slightly sigmoid to J-shaped with increasing Q's (quotients between successive numbers of trees). Apparently, the development of a diameter distribution is under strong biological control.

Problem 2

Better understand the ecological relationships between wildlife habitat and forest management  
FY 96 Research Attainments

Publications

Cooperative

Krusic, Rachel A.; Neefus, Chris D.; Yamasaki, Mariko; Pekins, Peter J. 1996. Echolocation calls of bats in the White Mountain National Forest: species identification using multivariate analysis. *Bat Research News*. 36(4): 81. Abstract.

(Unit supplied funding through Cooperative Agreement.)

Krusic, Rachel A.; Neefus, Chris D.; Yamasaki, Mariko; Pekins, Peter J. 1996. Habitat associations of bat species in the White Mountain National Forest. *Bat Research News*. 36(2-3): 27. Abstract.

(Unit supplied funding through Cooperative Agreement.)

Krusic, Rachel A.; Yamasaki, Mariko; Neefus, Christopher D.; Pekins, Peter J. 1996. Bat habitat use in White Mountain National Forest. *Journal of Wildlife Management*. 60 (3): 625-631.

Extramural

Neefus, Chris D.; Krusic, Rachel A. 1996. Computer-aided identification of bat species based on broadband detection of echolocation calls. *Bat Research News*. 36(4): 94. Abstract.

(Unit supplied funding through Cooperative Agreement.)

Sasse, David B.; Pekins, Pete J. 1996. Summer roosting ecology of cavity-dwelling bats in the White Mountain National Forest. *Bat Research News*. 36(2-3): 31. Abstract.

(Unit supplied funding through Cooperative Agreement.)

Attainment

Composite treatment of flight and foraging activity of bat species using the forests of the White Mountains revealed concentrated activity at forest edges and was uniformly at least 50% less within forest stands. Overmature hardwood stands and regenerating softwood and hardwood types were important activity areas for bats. Male *Myotis lucifugus* represented 56% of the bats trapped. Data indicate a matrix of forest types and age classes, in combination with roads, trails, and aquatic habitat, provide summer habitat for bats. Identification of search phase echolocation sequences of the nine species of bats in the NE US is important to any remote studies of habitat use or population monitoring. Multivariate discriminant analysis was used to correctly classify composite non-myotid passes with 100% accuracy; and myotid passes were correctly identified to genus with 97% accuracy. This work provides a visual key to echolocation signatures of the nine bat species in the NE US and statistically describes species search phase echolocation passes, using AnaBat II broadband detectors and prototype software developed at the University of New Hampshire. Radio-tagged female *Myotis septentrionalis* in the White Mountain select day roost sites in stands with higher average live tree diameters and snag basal areas (3.9 m<sup>2</sup>/ha) than found in surrounding forest stands. Roost sites were found in hardwood cavity trees that had recently died in contrast to the more decayed condition of snags in the surrounding area. A random survey of 104 potential roost trees using broadband bat detectors in 1994 noted 28 with some bat activity; 5 were visually confirmed as roost trees.

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**Problem 3**                      **Need to preserve undisturbed areas to study natural succession and impacts of global change**  
**FY 96 Research Attainments**

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**Publications**

**Research Unit**                      Rice, Wanda B.; Howard, Theodore; Congalton, Russel; Rubin, Fay. 1996. Identifying shore-front lands with high land use conversion potential in northern New Hampshire using a geographic information system. In: Brisette, John C., comp. 76th winter meeting of the New England Society of American Foresters; 1996 March 19-21; Lowell, MA. [Place of publ. unknown]: New England Society of American Foresters: 20-21. Poster Abstract.

**Extramural**                      Muzika, Rose-Marie; Hunsucker, Robert; DeMeo, Tom. 1996. Botanical reconnaissance of Big Run Bog Candidate Research Natural Area. Gen. Tech. Rep. GTR-NE-223. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 15.

(Reconnaissance funded in part through Station RNA Program administered by NE-4154.)

Royte, Joshua L.; Sperduto, Daniel D.; Lortie, John P. 1996. Botanical reconnaissance of Nancy Brook Research Natural Area. Gen. Tech. Rep. NE-216. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 23.

(Unit provided funding through Cooperative Agreement-RNA program.)

Selva, Steven B. 1996. Using lichens to assess ecological continuity in northeastern forests. In: Davis, Mary B., comp., ed. Eastern old-growth forests: prospects for rediscovery and recovery. Washington, DC: Island Press: 35-48.

**Attainment**

In 1995 the Project, using Station allocated Research Natural Areas funding, sponsored a survey of bryophyte (mosses and liverworts) abundance on six RNAs and candidate RNAs on the White Mountain National Forest. Natalie Cleavitt of Cornell University found 48 liverwort species and 163 moss species and three varieties. Only 12 liverworts and 30 mosses were common to all six RNAs. Cleavitt collected seven species not previously reported for New Hampshire, including the globally rare *Philonotis yezoana* and *Splachnum rubrum*, which are recommended for inclusion in the State list of rare, threatened and endangered species.

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**Problem 4**                      **Need to preserve integrity of older plantations to document responses to environmental change**  
**FY 96 Research Attainments**

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**Publications**

                                 none

**Attainment**

                                 No additional field work was done in the past year but a book, "Guide to Forest Genetics Field Trials at the Northeastern Forest Experiment Station," is being prepared. The format is similar to one prepared in North Central last year. Each planting will be represented by a page listing material planted, location, design, growth, survival, recommended maintenance, etc., planting map, and maps on how to locate the planting. The list is expected to exceed 200 plantings without listing any of the hybrid poplars and many of the older hardwood and conifer trials established prior to 1950.

**Northeastern Forest Experiment Station  
Forest Environment Research  
Research Work Unit 4251**

**Wildlife Communities and Habitat Relationships in New England Forests  
DeGraaf, Richard M., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Wildlife community responses to alternative silvicultural systems in northern hardwoods	FER	320	1.0	2		
2. Relationship between stand structure and abundance of mammals in New England oak forests	FER	300	2.0	3	2	4
3. Effects of forest management on amphibians and amphibian habitats in a changing global environ.	FER	115	.9	1		
4. Measurement of people's beliefs, values, and reactions to forest and wildlife habitat mgmt.	FER	110	1.0	3		

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**Problem 1**                      **Wildlife community responses to alternative silvicultural systems in northern hardwoods**  
**FY 96 Research Attainments**

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**Publications**

- Research Unit**                      DeGraaf, Richard M. 1995. Nest predation rates in managed and reserved extensive northern hardwood forests. *Forest Ecology and Management*. 79: 227-234.
- DeGraaf, Richard M.; Rappole, John H. 1995. *Neotropical migratory birds: natural history, distribution, and population change*. Ithaca, NY: Cornell University Press. 676.

**Attainment**

Habitat relationships for 330 New England wildlife species were described in terms of features that could be measured on aerial photographs. Relationships to soil elevation, or water were keyed spatially to soil maps, topographic maps, and wetland maps. Algorithms were written to search landscape data in GIS format and produce maps of potential habitat availability. These maps are being validated by field surveys for selected species. Three landscapes will be subject to wildlife habitat modelling: a field/forest/suburban landscape in southern New England, a northern hardwood forest in central New England, and a spruce-fir forest in northern New England.

Predation by white-footed mice on small and large eggs confirmed that mice are predators of small eggs (e.g., the size of passerine Neotropical migrants' eggs). The abundance and ubiquity of mice make them potentially significant nest predators; eggs susceptible to such predation must be used in field research to estimate their impact.

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**Problem 2**                      **Relationship between stand structure and abundance of mammals in New England oak forests**  
**FY 96 Research Attainments**

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**Publications**

**Research Unit**                      Healy, William M. 1994. Ecosystem management: policies and procedures for effective implementation in the Northeast. *Northeast Wildlife*. 51: 81-89.

Healy, William M. 1995. Wildlife use of oak forests. *Wildlife Habitats*. 11 (1): 1-2, 7.

Smith, Harvey R.; Remington, Charles L. 1996. Food specificity in interspecies competition. *BioScience*. 46 (6): 436-447.

**Cooperative**                      Cook, Stephen P.; Smith, Harvey R.; Hain, Fred P.; Hastings, Felton L. 1995. Predation of gypsy moth (Lepidoptera: Lymantriidae) pupae by invertebrates at low small mammal population densities. *Environmental Entomology*. 24 (5): 1234-1238.

Hastings, Felton L.; Hain, Fred P.; Smith, Harvey R.; Odell, Thomas M.; Cook, Stephen P. 1995. Natural enemies of the gypsy moth at the leading edge of its invasion into the southern U.S. In: Hain, Fred P.; Salom, Scott M.; Ravlin, William F.; Payne, Thomas L.; Raffa, Kenneth F., eds. Behavior, population dynamics and control of forest insects. Proceedings of the IUFRO joint conference; 1994 February 6-11; Maui, HI. Wooster, OH: The Ohio State University, Ohio Agricultural Research and Development Center: 474-490.

Hastings, Fenton L.; Hain, Fred P.; Smith, Harvey R.; Odell, Thomas M. 1995. Natural enemies of the gypsy moth at the leading edge of its invasion into the southern U.S. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 76. Abstract.

Scott, J. Michael; Ables, Ernest D.; Edwards, Thomas C.; Eng, Robert L.; Gavin, Thomas A.; Healy, William M. 1995. Conservation of biological diversity: perspectives and the future for the wildlife profession. *Wildlife Society Bulletin*. 23 (4): 646-657.

**Extramural**                      Griesemer, Sara J.; DeGraaf, Richard M.; Fuller, Todd K. 1994. Effects of excluding porcupines from established winter feeding trees in central Massachusetts. *Northeast Wildlife*. 51: 29-33.

Sadighi, Kay; DeGraaf, Richard M.; Danielson, William R. 1995. Experimental use of remotely-triggered cameras to monitor occurrence of timber rattlesnakes (*Crotalus horridus*). *Herpetological Review*. 26 (4): 189-190.

**Attainment**

Introduced species have already had a great effect on eastern oak forests, and future purposeful and accidental introductions are likely. Biological control is generally viewed as an environmentally friendly alternative to chemical control. However, the introduction of alien species, whether or not part of a biological control plan, is not without risk. Alien species themselves, for example, the gypsy moth, may become targets of biological control efforts. Because the successful spread of an alien species may be due to the lack of native parasites, predators, and pathogens, scientists search for and move suitable alien species, usually parasitoids, from their native areas to exotic locations to achieve a more natural, and hopefully permanent, control. Although most such introductions probably fail to become established, the few that do tend to produce serious ecological disturbances. Guidelines for biological control management should stress the risks from introducing terrestrial vertebrates and the relatively generalist arthropods. With properly quarantined experiments preceding releases, host-specific parasitoids and weed-controlling herbivores are safer.

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<b>Problem 3</b>	<b>Effects of forest management on amphibians and amphibian habitats in a changing global environ.</b> <b>FY 96 Research Attainments</b>
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**Publications**

<b>Research Unit</b>	Brooks, Robert T. 1996. Assessment of two camera-based systems for monitoring arboreal wildlife. Wildlife Society Bulletin. 24 (2): 3 p.
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**Attainment**

Macroinvertebrates were sampled once monthly for three months (April-June) at five locations in each pond. Pond water levels were measured weekly during the period when each pond held water. Precipitation and deposition inputs were measured weekly at an NADP site. Amphibian use of 16 forested stands were sampled monthly using 60 systematically located cover boards in each stand. Land use and land cover within the watershed for the year 1939 were digitized. Other data layers for the study area are being identified and acquired.

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<b>Problem 4</b>	<b>Measurement of people's beliefs, values, and reactions to forest and wildlife habitat mgmt.</b>
	<b>FY 96 Research Attainments</b>

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**Publications****Research Unit**

Daigle, John J.; Muth, Robert M.; Zwick, Rodney R.; Glass, Ronald J. 1996. The importance of social networks among trappers in six northeastern states. In: Proceedings, 6th international symposium on society and resource management: social behaviour, natural resources, and the environment; 1996 May 18-23; University Park, PA. University Park, PA: The Pennsylvania State University: 45. Abstract.

Daigle, John J.; Muth, Robert M.; Zwick, Rodney R.; Glass, Ronald J. 1996. Trapping-related values and motivations among trappers in the northeastern United States: a factor-analytic study. In: Proceedings, 6th international symposium on society and resource management: social behavior, natural resources, and the environment; 1996 May 18-23; University Park, PA. University Park, PA: The Pennsylvania State University: 47. Abstract.

Daigle, John J.; Muth, Robert M.; Zwick, Rodney R.; Glass, Ronald J. 1995. Social values and motivations of trappers in six northeastern states. In: Thompson, Jerrilyn Lavarre; Lime, David W.; Gartner, Bill; Sames, Wayne M., comps. Proceedings of the 4th international outdoor recreation & tourism trends symp. and 1995 national recreation resources planning conference; 1995 May 14-17; St. Paul, MN. St. Paul, MN: University of Minnesota, College of Natural Resources and Minnesota Extension Service: 531-535.

**Attainment**

In 1994, a mailback questionnaire was administered to a sample of trapping license holders in the states of Maine, Massachusetts, New York, Pennsylvania, Vermont, and West Virginia. Approximately 2,279 usable questionnaires were returned, for an overall response rate of 65 percent. Factor analysis identified five major underlying dimensions, or factors, associated with trapping: lifestyle orientation, affiliation with other people, wildlife management, nature appreciation, and personal achievement.

In 1995, face-to-face interviews were conducted with 92 trappers in the six northeastern states of Maine, Massachusetts, New York, Pennsylvania, Vermont, and West Virginia. A semi-structured interview protocol was employed to explore, among other things, trapping-related affiliations, social relationships, and interactions of respondents. The social network analysis in this study involved the construction of social maps of interpersonal relationships and the analysis of the structural patterns that make up an ego-centered network of relationships. Analysis indicates that trapping-related networks are composed of a variety of different relational linkages and patterns of network structures.

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**Northeastern Forest Experiment Station  
Forest Environment Research  
Research Work Unit 4252**

**Atlantic Salmon Habitat Restoration Ecology and Management  
DeGraaf, Richard (Acting), Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Optimum habitat conditions for juvenile salmon, biological factors that influence fry and parr	FER	240	.0			
2. Determine interspecies interactions from stocking salmon fry in streams with resident fish	FER	28	.0			

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**Problem 1**                      **Optimum habitat conditions for juvenile salmon, biological factors that influence fry and parr**  
**FY 96 Research Attainments**

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**Publications**

none

**Attainment**

For trout and salmon streams on the Green Mountain and White Mountain National Forests, techniques have been developed and refined to relate stream habitat data to geo-referenced locations in GIS, and relating these data to landscape characteristics.

Parr from fry stocking were captured in fall, late winter, and early spring. Maturation, energy stores, biochemical indices of growth are being measured. Results will direct the next sampling effort.

The use of naturally abundancies of multiple stable isotopes (e.g., strontiums, nitrogen, carbon) are being evaluated as chemical tags for the identification of Atlantic salmon. If successful, the tag will isotopically characterize streams and the isotopic "fingerprint" will enable the linking of migrating and returning Atlantic salmon to natal tributaries.

The state of science of Atlantic salmon research will be synthesized in a planned workshop "Integrating across scales; predicting patterns of change in Atlantic salmon."

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<b>Problem 2</b>	<b>Determine interspecies interactions from stocking salmon fry in streams with resident fish</b>
	<b>FY 96 Research Attainments</b>

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**Publications**

none

**Attainment**

During the first field season on this project, we sampled seventeen sites of varying salmonid species composition in the West and White rivers of Vermont. Via electrofishing with USFS and VTFW biologists, we collected a total of 1,777 Atlantic salmon, 165 brown trout, 694 brook trout, and 665 rainbow trout from late-July to mid-September 1995 from these sites. In addition to taking total lengths and weighing a maximum of 50 of each age group per species, we used a gastric lavage technique to remove the stomach contents of 10 fish of each age group per species. Stomach contents were frozen on dry ice for later analysis. At each site prior to electrofishing, we randomly set two drift nets on a transect that was randomly chosen from four 10-m blocks within a 40-m stream section. Therefore, the total number of drift samples taken at each site was eight. In the lab, drift samples and stomach contents are identified to the lowest practicable taxon, counted, and measured using an ocular micrometer and digitizing software. Data from these samples are coded and directly entered into a database. Approximately one-third of the samples from 1995 have been completed. We are now in the process of determining diet overlaps of salmon and trout, as well as, determining prey selectivities based on prey available in drift samples.

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Northeastern Forest Experiment Station  
Forest Environment Research  
Research Work Unit 4352

Dynamics of Atmosphere, Vegetation, Soil & Water in Mature & Harvested Forests in  
New England

Eagar, Christopher, Project Leader

FY 96 Research Attainments  
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. To what degree do harvesting and/or acid precip. deplete nutrient capitals of New England	FER	490	2.3	5	2	1
2. What is the sequence of regeneration following conventional and intensive harvesting in forests	FER	57	.3			
4. What are the implications of highly acidic Cone Pond for understanding acidification of ecosystems	FER	229	1.4	1		
5. Pathways of water and nutrient movement through forest soils. Can a useful model be developed?	FER	114	1.0	2		
M1. The HBEF will be maintained for ecosystem research biosphere reserve and for LTER	FER	346	1.0	2	1	1

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**Problem 1**                      **To what degree do harvesting and/or acid precip. deplete nutrient capitals of New England**  
**FY 96 Research Attainments**

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**Publications**

**Research Unit**                      Eagar, Christopher; Nicholas, N.S. 1996. Old-growth spruce-fir in the southern Appalachians: stand dynamics and tree condition over an eleven year period. Supplement to Bulletin of the Ecological Society of America. 77(3): 124. Abstract.

Hislop, J.E.; Hallett, R.A., Hornbeck, J.W. 1996. Microwave digestion of forest soil and plant tissue samples. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 396-397. Poster.

Pardo, L.H.; Driscoll, C.T. 1996. Critical loads for nitrogen deposition: case studies at two northern hardwood forests. Water, Air, and Soil Pollution. 89: 105-128.

Pardo, L.H.; Driscoll, C.T.; Likens, G.E. 1995. Patterns of nitrate loss from a chronosequence of clear-cut watersheds. Water, Air, and Soil Pollution. 85: 1659-1664.

Pardo, L.J. 1996. Response of natural abundance of  $^{15}\text{N}$  in forest soils to high nitrate loss following clearcutting. Supplement to Bulletin of the Ecological Society of America. 77(3): 340. Abstract.

**Cooperative**                      Hallett, R.A.; Hornbeck, J.W. 1996. Cation depletion in New England forests. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 404-405. Poster.

**Extramural**                      Campbell, John. 1996. Processes affecting the acid-base status of surface waters in the Lye Brook Wilderness, Vermont. Durham, NH: University of New Hampshire. 120. M.S. thesis.

Hallett, Richard A. 1996. Foliar and soil nutrient relationships in red oak and white pine forests. Durham, NH: University of New Hampshire. 93. Ph.D. dissertation.

**Attainment**

Red oak and white pine forests on sandy soils of the northeastern U.S. may have been depleted of nutrient cations by acid precipitation and intensive land use. Foliar calcium in oak was 5257 mg calcium kg<sup>-1</sup> dry matter, or over 3 times the amount of calcium in white pine foliage. Red oak also has more magnesium, potassium and nitrogen than white pine. Foliar aluminum concentration for white pine, 132 mg aluminum kg<sup>-1</sup> dry matter, is twice that of red oak foliage. Foliar calcium and nitrogen are correlated with basal area increment. Foliar calcium:aluminum ratios and magnesium levels in pine foliage suggest a risk to tree health. In the organic horizons of both oak and pine forests, bases occupied 80% of the exchange sites. However, in the mineral soil, aluminum occupied 96% of the exchange sites. These data indicate that both forest types are susceptible to nutrient imbalances and deficiencies that result from past agricultural use, atmospheric deposition, and harvest.

A critical load of a pollutant is the level of input below which no harmful ecological effects occur to a complex ecosystem. Four mass and charge balance methods were used to calculate the critical load of nitrogen to two northern hardwood forests. At both Hubbard Brook and Huntington Forest the critical load for nitrogen with respect to acidity was exceeded, and at HBEF the critical load with respect to nutrient imbalances and eutrophication was exceeded in recent years.

Nitrogen dynamics, including seasonal patterns of nitrate in streamwater, changes in N capital, and N retention, were evaluated from a chronosequence of clearcut watersheds at HBEF.

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**Problem 2**                      **What is the sequence of regeneration following conventional and intensive harvesting in forests**  
**FY 96 Research Attainments**

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**Publications**

none

**Attainment**

In 1981, a 6 ha central hardwood stand in Connecticut was mechanically whole-tree clearcut in order to evaluate initial stages of forest regeneration. During this reporting period, permanent vegetation plots within this study area were remeasured as part of the long-term study.

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<b>Problem 4</b>	<b>What are the implications of highly acidic Cone Pond for understanding acidification of ecosystems</b>
	<b>FY 96 Research Attainments</b>

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**Publications**

<b>Research Unit</b>	Bailey, Scott W.; Hornbeck, James W.; Driscoll, Charles T.; Gaudette, Henri E. 1996. Calcium inputs and transport in a base-poor forest ecosystem as interpreted by Sr isotopes. Water Resources Research. 32 (3): 707-719.
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**Attainment**

Depletion of calcium in forests and its effects on forest health are poorly quantified. Depletion has been difficult to document due to limitations in determining rates at which calcium becomes available for ecosystem processes through weathering, and difficulty in determining changes in ecosystem storage. We coupled a detailed analysis of strontium isotopic composition with a mass balance at Cone Pond Watershed, New Hampshire, in order to further constrain estimates of these processes. By conducting a mass balance on atmospherically derived calcium, it is possible to distinguish calcium weathering losses from calcium leaches from ecosystem pools. The calcium weathering rate estimated by this method was less than half of that determined by mass balance assuming steady state conditions. These findings are useful in prescribing forest management activities that will protect nutrient capitals, and in further understanding impacts of atmospheric deposition.

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**Problem 5**                      **Pathways of water and nutrient movement through forest soils. Can a useful model be developed?**  
**FY 96 Research Attainments**

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**Publications**

- Research Unit**                      Federer, C.A.; Vorosmarty, C.; Fekete, B. 1996. Intercomparison of methods of calculating potential evaporation in regional and global water balance models. *Water Resources Research*. 32 (7): 2315-2321.
- Harris, M.M.; Safford, L.O. 1996. Effects of season and four tree species on soluble carbon content in fresh and decomposing litter of temperate forests. *Soil Science*. 161 (2): 130-135.

**Attainment**

Global climate change is likely to alter the magnitude and distribution of evaporation, streamflow, and plant-available soil water. Ability to simulate land surface water budgets over large areas requires the estimation of evaporation from a variety of land surfaces within the simulated domains. Nine methods of estimating potential evaporation (PE) were evaluated at seven locations from Alaska to Puerto Rico. For annual PE, the nine methods of estimation generally agreed; however, for some locations differences among methods were hundreds of millimeters per year. No method was consistently low or high. Use of 5-day or monthly data did not greatly degrade results, so use of monthly data to generate PE estimates appears warranted in global water balance models.

Decomposition of plant material is an important component in the study of forest ecosystems because of its critical role in nutrient cycling. The turnover of nutrients in forest soil organic matter depends on, among other factors, a readily available supply of C for decomposer organisms. Levels of water soluble C in leachate from four species of forest floor material were compared at five sampling periods in 1988. Levels of soluble C released from forest floor material depended on the species of substrate, and the degree of decomposition of the material. Sugar maple leachate averaged 1.7 times more soluble C than leachate from Norway spruce, red pine, and black locust. Average levels of soluble C for all samples in October were more than 2 times higher than those from July, August, September, and December.

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**Problem M1**

**The HBEF will be maintained for ecosystem research biosphere reserve and for LTER  
FY 96 Research Attainments**

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**Publications****Research Unit**

Martin, C. Wayne. 1996. Water quality—an overview. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 121-126.

Martin, C. Wayne; Hornbeck, James W. 1996. Sediment as a nonpoint source pollutant can be controlled during harvesting of northern hardwood forests. In: Proceedings of the 6th federal interagency sedimentation conference; 1996 March 10-14; Las Vegas, NV. [Place of publ. unknown]: [Publisher name unknown]: X-78-X-85.

**Cooperative**

Aber, John D.; Ollinger, Scott V.; Federer, C. Anthony; Reich, Peter B.; Goulden, Michael L.; Kicklighter, David W. 1995. Predicting the effects of climate change on water yield and forest production in the northeastern United States. *Climate Research*. 5: 207-222.

**Extramural**

Likens, G.E.; Driscoll, C.T.; Buso, D.C. 1996. Long-term effects of acid rain: response and recovery of a forest ecosystem. *Science*. 272: 244-246.

**Attainment**

Long-term data from the Hubbard Brook Experimental Forest, New Hampshire, suggest that although changes in stream pH have been relatively small, large quantities of calcium and magnesium have been lost from the soil complex and exported by drainage water because of inputs of acid rain and declines in atmospheric deposition of base cations. As a result, the recovery of soil and streamwater chemistry in response to any decreases in acid deposition will be delayed significantly.

Rapid and simultaneous changes in temperature, precipitation, and the atmospheric concentration of CO<sub>2</sub> are predicted to occur over the next century. Simple, well-validated models of ecosystem function are required to predict the effects of these changes. An improved version of a forest carbon and water balance model and the application of the model to predict stand- and regional-level effects of changes in temperature, precipitation, and atmospheric CO<sub>2</sub> concentration has been developed. PnET-II is a simple, generalized, monthly time-step model of water and carbon balances derived by nitrogen availability as expressed through foliar N concentration. The model was parameterized and run for 4 forest/site combinations including HBEF and validated against available data for water yield, gross and net carbon exchange and biomass production. The model was then run for the entire New England/New York (USA) region using a 1 km resolution geographic information system and expected changes in climate.

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**Northeastern Forest Experiment Station  
Forest Environment Research  
Research Work Unit 4353**

**Sustainable Forest Ecosystems in the Central Appalachians  
Adams, Mary Beth, Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Information needed on historical disturbance patterns and influences on ecosystem processes	FMR	357	2.0			
2. Quantitative information needed about important ecosystem processes and impacts of disturbances	FER	536	3.0		1	6
3. Efficient and ecologically sound silvicultural alternatives must be developed to meet complex	FMR	446	1.5	4		2
4. Develop guidelines for variety of management and operation practices and develop tools to monitor	FER	447	1.5	3		3

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<b>Problem 1</b>	<b>Information needed on historical disturbance patterns and influences on ecosystem processes</b>
	<b>FY 96 Research Attainments</b>

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**Publications**

none

**Attainment**

A study has been initiated to address historical disturbance patterns, using discs cut from trees on the Fernow Experimental Forest. Stand data from 1922 are also being evaluated. Research on flooding effects of aquatic ecosystems are ongoing.

Inter-habitat variation in benthic community structure and function was found to be greater than variability among streams; similarly, organic matter variability was greater among habitats.

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**Problem 2**                      **Quantitative information needed about important ecosystem processes and impacts of disturbances**  
**FY 96 Research Attainments**

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**Publications****Cooperative**

Gilliam, Frank S.; Adams, Mary Beth; Yurish, Bradley M. 1996. Ecosystem nutrient responses to chronic nitrogen inputs at Fernow Experimental Forest, West Virginia. *Canadian Journal of Forest Research*. 26 (4): 196-205.

Gilliam, Frank S.; Turrill, Nicole L.; Adams, Mary Beth. 1995. Herbaceous-layer and overstory species in clear-cut and mature central Appalachian hardwood forests. *Ecological Applications*. 5 (4): 947-955.

Karle, Kenneth F.; Edwards, Pamela J.; Major, Elaine B. 1996. Streambed disturbance during and after restoration of Glen Creek, Denali National Park, Alaska. In: McDonnell, Jeffrey J.; Stribling, James B.; Neville, L. Robert; Leopold, Donald J., eds. *Watershed restoration management: physical, chemical, and biological considerations*. Amer. Water Res. Assoc. symp. proceedings; 1996 July 14-17; Syracuse, NY. Herndon, VA: American Water Resources Association: 351-360.

Pickens, Callie J.; Sharpe, William E.; Edwards, Pamela J. 1994. Early indicators of acidification: a whole-watershed approach to studying forest response. *Sch. of For. Resour. Annu. Rep. Vol. 10*. University Park, PA: The Pennsylvania State University, College of Agricultural Sciences. 7 p.

Tajchman, S.J.; Kochenderfer, J.N.; Fu, H. 1996. Water and energy balance of a forested Appalachian watershed. In: Kohn, Michael; Gertner, George Z., eds. *Caring for the forest: research in a changing world. Statistics, mathematics and computers. Proceedings of the meeting of IUFRO XX World Congress; 1995 August 6-12; Tampere, Finland*. Birmensdorf, Switzerland: Swiss Federal Institute for Forest, Snow and Landscape Research: 33. Abstract.

Yokum, Kevin A.; Johnson, Brent R.; Tipton, R. Clif; Tarter, Donald C.; Angradi, Ted R. 1996. Leaf species selection by the shredding stoneflies *Peltoperla arcuata* and *Tallaperla maria* (Plecoptera: Peltoperlidae). In: *Proceedings of the West Virginia Academy of Science 1994: paper of the 69th annual session; 1994 April 23; Fairmont, WV. Vol. 66*. Morgantown, WV: West Virginia Academy of Science: 34-42.

**Extramural**

Ries, Robert D.; Perry, Sue A. 1995. Potential effects of global climate warming on brook trout growth and prey consumption in central Appalachian streams, USA. *Climate Research*. 5: 197-206.

**Attainment**

Our understanding of the effects of acidic deposition on forest ecosystems was advanced this year. Ecosystem response to chronic nitrogen inputs at the Fernow Experimental Forest was quantified and the important conclusion that some of our watersheds may be nitrogen saturated was published. Early indicators of acidification were developed. The water and energy balances for our main control watershed were developed using micrometeorological techniques. The relationship between the herbaceous layer and overstory species was examined for several stands; this "link" between strata can be influenced by management activities such as cutting. Detailed life history and food preference information was published for two important aquatic insects: *Peltoperla arcuata* and *Tallaperla maria*, providing basic information for evaluating population distributions. Based on modelling studies of global warming effects, brook trout populations could benefit from increased growth rates in spring and fall or suffer from shrinking habitat and reduced growth rates in summer, depending on the effects of temperature change on food availability.

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Problem 3

Efficient and ecologically sound silvicultural alternatives must be developed to meet complex  
FY 96 Research Attainments

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Publications

Research Unit

Baumgras, John E.; Miller, Gary W.; LeDoux, Chris B. 1995. Economics of hardwood silviculture using skyline and conventional logging. In: Lowery, Glenn; Meyer, Dan, eds. *Advances in hardwood utilization: following profitability from the woods through rough dimension*. Proceedings of the 23rd annual hardwood symposium; 1995 May 17-20; Cashiers, NC. Memphis, TN: National Hardwood Lumber Association: 5-17.

Miller, Gary W. 1996. Epicormic branching on Central Appalachian hardwoods 10 years after deferment cutting. Res. Pap. NE-702. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9.

Miller, Gary W.; Wood, Petra Bohall; Nichols, Jeffrey V. 1996. Two-age silviculture—an innovative tool for enhancing species diversity and vertical structure in Appalachian hardwood. In: Eskew, Lane G., comp. *Forest health through silviculture*. Proceedings of the 1995 national silviculture workshop; 1995 May 8-11; Mescalero, NM. Gen. Tech. Rep. RM-GTR-267. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 175-182.

Schuler, Thomas M.; Miller, Gary W. 1996. Guidelines for using tree shelters to regenerate northern red oak. In: Brissette, John C., ed. *Proceedings of the tree shelter conference*; 1995 June 20-22; Harrisburg, PA. Gen. Tech. Rep. NE-221. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 37-45.

Cooperative

Luppold, William G.; Baumgras, John E. 1995. Price trends and relationships for red oak and yellow-poplar stumpage, sawlogs, and lumber in Ohio: 1975-1993. *Northern Journal of Applied Forestry*. 12 (4): 168-173.

Luppold, William G.; Baumgras, John E. 1995. Relationships among sawlog price trends, species & quality examined. *National Hardwood Magazine*. September: 37-38.

Attainment

Results of more than 5 years of research on the use of tree shelters for regenerating northern red oak were synthesized to produce guidelines for tree shelter usage. Deferment cutting/two-age silviculture was found to increase diversity in vertical structure within stands, with increased songbird density estimates, but decreased nesting survival. Epicormic branching increased significantly on upper log sections of black cherry, northern red oak, and basswood two years after deferment cutting, but yellow-poplar log grade was relatively unchanged. Skyline cable logging and conventional logging costs were evaluated for several silvicultural methods. Harvesting systems were found to have less impact on harvesting revenue than silvicultural methods or roundwood prices, and hardwood lumber markets were found to significantly affect economic trade-offs associated with forest management alternatives. A wildlife research program was initiated.

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<b>Problem 4</b>	<b>Develop guidelines for variety of management and operation practices and develop tools to monitor FY 96 Research Attainments</b>
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**Publications**

- Research Unit**
- Angradi, Ted R. 1996. Inter-habitat variation in benthic community structure, function, and organic matter storage in 3 Appalachian headwater streams. *Journal of the North American Benthological Society*. 15 (1): 41-63.
- Angradi, Ted R.; Vinson, Mark R. 1995. Aquatic macroinvertebrate monitoring on national forests and Bureau of Land Management districts. *Bulletin of the North American Benthological Society*. 12 (3): 389-398.
- Kochenderfer, James N.; Smith, H. Clay; Crews, Jerry T. 1996. Effects of fertilization on the growth and development of a Japanese larch plantation in West Virginia. Res. Pap. NE-700. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8.

**Cooperative**

- Edwards, Pamela J. 1995. Chapter 2. Site characteristics. In: Effects of diflubenzuron on non-target organisms in broadleaf forested watersheds in the Northeast. FHM-NC-05-95. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area, State and Private Forestry: 6-12.
- Kochenderfer, James N.; Helvey, J.D.; Patric, James H.; Kidd, William E., Jr. 1996. Woodlot management: an introduction to water in the forest. Morgantown, WV: West Virginia University, Extension Service. 28.
- (Produced to supplement the Woodlot Management How it Grows video program. This is the supplement to the 8th in a series of eight videos.)
- Skog, Kenneth; Green, David; Barbor, R. James; Baumgras, John; Clark, Alexander III; Mason, Andrew. 1995. Building partnerships to evaluate wood utilization options for improving forest health. In: Eskew, Lane G., comp. Forest health through silviculture. Proceedings of the 1995 national silviculture workshop; 1995 May 8-11; Mescalero, NM. Gen. Tech. Rep. RM-GTR-267. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 153-161.

**Attainment**

This problem focuses on guidelines for forest management and methods to monitor effects. Increasing aquatic habitat complexity through installation of pool-forming structures (e.g. K-dams) will influence benthic community structure and function to a degree proportional to the amount of depositional habitat created. Aquatic invertebrate monitoring on National Forests and Bureau of Land Management Districts was evaluated, and recommendations developed for improving effectiveness of aquatic macroinvertebrate monitoring on federal lands.

Japanese larch were found to grow better on unfertilized plots on a nutrient-deficient site, perhaps due to competition with native hardwoods. A Woodlot Owner's Guide to the Water in the Forest, a primer on forest hydrology, was published as a supplement to the video, "Water in the Forest." A study was initiated, and partnerships built, to evaluate wood utilization options for improving forest health.

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**Northeastern Forest Experiment Station  
Forest Protection Research  
Research Work Unit 4454**

**Integrating the Ecological and Social Dimensions of Forest Ecosystem Management  
Twery, Mark J., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Methodologies for integrating ecological and social dimensions of forest management	FER	122	1.5	12	1	6
2. Application and evaluation of integrated approach to forest management problems	FPR	473	2.0	3	2	3
3. To improve mechanisms by which multiple-objective decisions concerning forest ecosystems are made	FPR	184	2.0	7	1	1

## Problem 1

Methodologies for integrating ecological and social dimensions of forest management  
FY 96 Research Attainments

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## Publications

## Research Unit

Dennis, Donald F.; Kuentzel, Walter F.; Tritton, Louise M.; Wang, Deane. 1996. Wetland externalities: implications for policy and decision-making. In: Dawson, Chad P., comp. Proceedings of the 1995 northeastern recreation research symposium; 1995 April 9-11; Saratoga Springs, NY. Gen. Tech. Rep. NE 218. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 148-151.

Echelberger, Herbert E. 1996. Forest Service research on the human dimensions of ecosystem management. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 344-350.

Glass, Ronald J.; More, Thomas A.; Echelberger, Herbert E. 1995. Natural resources and the quality of life in rural New England. In: Managing forests to meet peoples' needs: proceedings of the 1994 Society of American Foresters/Canadian Institute of Forestry convention; 1994 September 18-22; Anchorage, AK. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 327-328.

Glass, Ronald J.; Muth, Robert M.; More, Thomas A.; Kruse, Jack. 1995. Assessing developmental impacts on subsistence fishing: complications attributable to a mixed economic system. Society and Natural Resources. 8: 431-442.

Glass, Ronald J.; Walton, Gerald S. 1995. Recreation use of Upper Pemigewasset and Swift River Drainages, New Hampshire. Res. Pap. NE-701. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

More, Thomas A. 1996. Values, conflicts, and moral dilemmas in trapping. In: Proceedings, 6th international symposium on society and resource management: social behavior, natural resources, and the environment; 1996 May 18-23; University Park, PA. University Park, PA: The Pennsylvania State University: 47. Abstract.

More, Thomas A. 1996. Why definitional criticisms of ecosystem management don't hold water? In: Brissette, John C., comp. 76th winter meeting of the New England Society of American Foresters; 1996 March 20-23; Lowell, MA [Place of publ. unknown]: New England Society of American Foresters: 18. Poster Abstract.

More, Thomas A.; Stanat, Petra; Averill, James. 1996. Natural beauty. In: Brissette, John C., comp. 76th winter meeting of the New England Society of American Foresters; 1996 March 20-23; Lowell, MA. [Place of publ. unknown]: New England Society of American Foresters: 16. Poster Abstract.

More, Thomas A. 1996. Forestry's fuzzy concepts: an examination of ecosystem management. Journal of Forestry. 94 (8): 19-23.

Tritton, Louise M.; Wade, Gary L. 1996. Evaluating biodiversity of land units: scale, diversity types, and stakes. In: Integrating social science and ecosystem management: a national challenge: proceedings, national workshop of the conference on integrating social sciences and ecosystem management; 1995 December 12-14; Helen, GA. Athens, GA: U.S. Department of Agriculture, Forest Service, Southern Research Station and the Natural Resources Conservation Service: 130-133.

Twery, Mark J.; Gottschalk, Kurt W. 1996. Forest health: another fuzzy concept. Journal of Forestry. 94 (8): 20.

Wade, Gary L.; Sanders, Laurie. 1996. Vascular floras of shelterwood cuts: comparisons with a suite of reference areas. Supplement to Bulletin of the Ecological Society of America. 77(3): 463. Abstract.

**Cooperative**

Daigle, John J.; Muth, Robert M.; Zwick, Rodney R.; Glass, Ronald J. 1995. Social values and motivations of trappers in six northeastern states. In: Thompson, Jerrilyn Lavarre; Lime, David W.; Gartner, Bill; Sames, Wayne M., comps. Proceedings of the 4th international outdoor recreation & tourism trends symposium & the 1995 national recreation resource planning conference; 1995 May 14-17; St. Paul, MN. St. Paul, MN: University of Minnesota, College of Natural Resources and Minnesota Extension Service: 531-535.

Grove, J. Morgan; Zipperer, Wayne C. 1996. Social area index for landscape analysis. In: Integration of cultural and natural ecosystems across landscapes: application of the science. 11th annual landscape ecology symposium of International Association for Landscape Ecology; 1996 March 26-30; Galveston, TX. College Station, TX: Texas A&M University: 52-53. Abstract.

(Cooperator funded the research and travel; the senior author joined NE-4454 before completing work and unit supported his preparation and attendance at the symposium.)

Grove, J.M. 1996. Cause and consequence: the social dimensions of urban ecological restoration. In: Paved to protected: restoration in the urban/rural context. Society for Ecological Restoration 1996 international conference; 1996 June 17-22; New Brunswick, NJ. Madison, WI: Society for Ecological Restoration: 58. Abstract.

(Cooperating unit funded initial work. NE-4454 supported author's preparation and attendance at conference.)

Kuentzel, Walter F.; Tritton, Louise M.; Dennis, Donald F.; Wang, Deane. 1996. Thinking about water quality management: social values, wetland ecology, and landowner practices. In: Integrating social science and ecosystem management: a national challenge: proceedings of national workshop of the conference on integrating social sciences and ecosystem management; 1995 December 12-14; Helen, GA. Athens, GA: U.S. Department of Agriculture, Forest Service, Southern Research Station and the Natural Resources Conservation Service: 186-194.

Muth, Robert M.; Daigle, John J.; Zwick, Rodney R.; Glass, Ronald J. 1996. Trappers and trapping in advanced industrial society: economic and sociocultural values of furbearer utilization in the northeastern United States. *Sociological Spectrum*. 16: 421-436.

Stevens, T. H.; Field, Martha K.; More, Thomas A.; Glass, Ronald J. 1994. Contingent valuation of rare and endangered species: an assessment. In: Ready, Richard C., comp. Benefits and costs transfer in natural resource planning. West. Reg. Res. Publ. W-133. Lexington, KY: University of Kentucky, Department of Agricultural Economics: 471-487.

**Extramural**

More, Tom; Steering Committee. 1996. 1995 April 9-11; Saratoga Springs, NY. Gen. Tech. Rep. NE-218. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 286 p.

**Attainment**

We have continued to work with cooperators with expertise in sociology and social ecology, and we have expanded the scope of that work to include local and regional communities. Theoretical work on the framework for evaluating biodiversity continues. We have added additional areas within which we are evaluating biodiversity with the intent of validating the framework. We have identified and published links relating community values to wetlands, forest and agricultural management, and landowner practices.

Problem 2

Application and evaluation of integrated approach to forest management problems

FY 96 Research Attainments

Publications

Research Unit

Bove, James R.; Burbank, Diane H.; Capen, David E.; Wade, Gary L. 1996. Comparing tree productivity and ground flora composition between two ecological classification systems on the Green Mountain National Forest, Vermont. Supplement to Bulletin of the Ecological Society of America. 77(3): 47. Abstract.

Huyler, Neil K.; LeDoux, Chris B. 1996. Cut-to-length harvesting on a small woodlot in New England: a case study. In: Blinn, Charles R.; Thompson, Michael A., eds. Planning and implementing forest operations to achieve sustainable forests: Proceedings of papers presented at the joint meeting of the Council on Forest Engineering and IUFRO.; 1996 July 29-August 1; Marquette, MI. Gen. Tech. Rep. NC-186. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 102-108.

Twery, Mark J. 1996. Innovative techniques for integrating objectives for ecosystem management: the Northeast Decision Model. In: Kohl, Michael; Gertner, George Z., eds. Caring for the forest: research in a changing world. Statistics, mathematics and computers: proceedings of the meeting of IUFRO XX World Congress; 1995 August 6-12; Tampere, Finland. Birmensdorf, Switzerland: Swiss Federal Institute for Forest, Snow and Landscape Research: 183-188.

Cooperative

Barber, Klaus; Campbell, Joe; Crookston, Nick; Dahms, Cathy; Day, John; Mowerer, Todd. 1996. Mowerer, H.Todd, tech. comp. Decision support system for ecosystem management: an evaluation of existing systems. Gen. Tech. Rep. RM. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Palmer, James F.; Twery, Mark J. 1996. NED: a user controlled decision-support system for forest recreation environments. In: Thompson, Jerrilyn Lavarre; Lime, David W.; Gartner, Bill; Sames, Wayne M., comps. Proceedings of the 4th international outdoor recreation & tourism trends symposium & the 1995 national recreation resource planning conference; 1995 May 14-17; St. Paul, MN. St. Paul, MN: University of Minnesota, College of Natural Resources and Minnesota Extension Service: 376-380.

Thompson, Ralph L.; Wade, Gary L.; Straw, R. Allen. 1996. Natural and planted flora of the log mountain surface-mined demonstration area, Bell County, Kentucky. In: Daniels, W. Lee; Burger, James A.; Zipper, Carl E., eds. Successes and failures: applying research results to insure reclamation success: proceedings of the 13th annual meeting of the American Society for Surface Mining and Reclamation; 1996 May 18-23; Knoxville, TN. Blacksburg, VA: Virginia Polytechnic Institute and State University, Research Division: 484-503.

Extramural

Kenefic, Laura S. Wolslegel. 1995. Quantitative assessment of wildlife habitat in uneven-aged northern hardwood stands. Syracuse, NY: State University of New York. 202. M.S. thesis.

Quinlan, Paul M. 1996. An assessment of wildlife habitat characteristics in Adirondack selection system stands. NY, NY: State University of New York. 110. M.S. thesis.

**Attainment**

Decision-support tools for forest landowners and managers have been distributed and are being used by the public. We have conducted training sessions and established priorities for further enhancement of existing products and identified research needs for further capabilities. The Forest Stewardship Planning Guide, a program for landowners and the general public to evaluate potential alternative goals for forest land, is in its second printing with minor revisions, and further additions are planned. The Stand Inventory Processor and Simulator (NED/SIPS) has also been revised in response to user requests and is in use throughout the Northeast. NEWILD, a wildlife habitat database synthesized from other work in the Northeast, is nearing publication. We have continued to refine our concepts of the relationship of landscape-scale analysis to stand-level forest manipulation. We are beginning the integration of additional social variables into the mix of considerations in developing forest management alternatives.

Problem 3

To improve mechanisms by which multiple-objective decisions concerning forest ecosystems are made  
FY 96 Research Attainments

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Publications

Research Unit

Dennis, Donald F.; Sendak, Paul E. 1996. Stumpage price trends in New England: 1964-1995. In: Brissette, John C., comp. 76th winter meeting of the New England Society of American Foresters; 1996 March 19-21; Lowell, MA. [Place of publ. unknown]: New England Society of American Forests: 4. Poster Abstract.

Dennis, Donald F. 1995. Assessing and incorporating extra market values in decisions concerning forest ecosystems. In: Sessions, John; Brodie, J. Douglas, eds. Management systems for a global economy with global resource concerns: proceedings of the 1994 symposium on systems analysis in forest resources; 1994 September 6-9; Pacific Grove, CA. Bethesda, MD: Society of American Foresters: 161-166.

Dennis, Donald F. 1996. Review of "forest resources in Europe 1950-1990". The Quarterly Review of Biology. 71 (3): 411-412.

Glass, R.J.; More, T.A.; Echelberger, H.E. 1996. Incorporating broad-based public values into natural resource decisionmaking. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 321-327.

More, T.A.; Glass, R.J. 1996. Human values and their role in forest management. In: Sustaining forest, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 7-9.

More, Thomas A. 1995. Appendix B: Facts, values, and the human dimensions of global change. In: Emery, Marla; Paananen, Donna M. Humans, forests, and global environmental changes: planning a social science research agenda. Gen. Tech. Rep. NE-212. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 21-22.

More, Thomas A.; Dustin, Daniel L.; Knopf, Richard C. 1996. Behavioral consequences of campground user fees. Journal of Park and Recreation Administration. 14 (1): 81-93.

Cooperative

White, Christopher M.; Cobus, Mike; Manning, Robert E.; Seffel, Joel; More, Tom. 1996. Trends in the economics of sustainable outdoor recreation and tourism: the future of outdoor recreation fees for the public sector. In: Thompson, Jerrilyn Lavarre; Lime, David W.; Gartner, Bill; Sames, Wayne M., comps. Proceedings of the 4th international outdoor recreation & tourism trends symposium & the 1995 national recreation resource planning conference; 1995 May 14-17; St. Paul, MN. St. Paul, MN: University of Minnesota, College of Natural Resources and Minnesota Extension Service: 285-293.

Extramural

Rickenbach, Mark G. 1996. Ecosystem management and NIPF landowners in Franklin County, Massachusetts: an assessment of attitudes. Amherst, MA: University of Massachusetts. 128 p. M.S. thesis.

(Work unit provided funding and consultation for this research through a cooperative agreement. Unit scientist served on Thesis committee.)

Attainment

We have continued to increase our understanding of how multiple-objective decisions are made. We have completed a study assessing landowner attitudes toward ecosystem management in Massachusetts, and are making progress analyzing the rankings of hypothetical management alternatives for Green Mountain National Forest by a variety of interested parties.

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**Northeastern Forest Experiment Station  
Forest Protection Research  
Research Work Unit 4455**

**Northern Stations Global Change Research Program  
Birdsey, Richard A., (PM), Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Global Change Research	FPR	1506	1.5		45	2
1A. Global Change Research (Continued)	FPR	0	.0	1	37	
1B. Global Change Research (Continued)	FPR	0	.0	3	37	
1C. Global Change Research (Continued)	FPR	0	.0	2	21	1

Problem 1

Global Change Research  
FY 96 Research Attainments

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Publications

Cooperative

Alexeyev, V.; Birdsey, R.; Stakanov, V.; Korotkov, I. 1995. Carbon in vegetation of Russian forests: methods to estimate storage and geographical distribution. *Water, Air and Soil Pollution*. 82: 271-282.

Plantinga, Andrew J.; Birdsey, Richard A. 1994. Optimal forest stand management when benefits are derived from carbon. *Natural Resource Modeling*. 8 (4): 373-387.

Extramural

Aber, John D.; Ollinger, Scott V.; Federer, C. Anthony; Reich, Peter B.; Goulden, Michael L.; Kicklighter, David W. 1995. Predicting the effects of climate change on water yield and forest production in the northeastern United States. *Climate Research*. 5: 207-222.

Aber, John D.; Reich, Peter B.; Goulden, Michael L. 1996. Extrapolating leaf CO<sub>2</sub> exchange to the canopy: a generalized model of forest photosynthesis compared with measurements by eddy correlation. *Oecologia*. 106: 257-265.

Arneth, A.; Kelliher, F.M.; Bauer, G.; Hollinger, D.Y.; Byers, J.N.; Hunt, J.E. 1996. Environmental regulation of xylem sap flow and total conductance of *Larix gmelinii* trees in eastern Siberia. *Tree Physiology*. 16: 247-255.

Bailey, Scott W.; Hornbeck, James W.; Driscoll, Charles T.; Gaudette, Henri E. 1996. Calcium inputs and transport in a base-poor forest ecosystem as interpreted by Sr isotopes. *Water Resources Research*. 32 (3): 707-719.

Brooks, Robert T.; Doyle, Katherine L. 1995. White-belted coloration in a masked shrew, *Sorex cinereus*, from Massachusetts. *Canadian Field-Naturalist*. 108: 491-492.

Coleman, M.D.; Dickson, R.E.; Isebrands, J.G.; Karnosky, D.F. 1995. Carbon allocation and partitioning in aspen clones varying in sensitivity to tropospheric ozone. *Tree Physiology*. 15: 593-604.

Coleman, M.D.; Dickson, R.E.; Isebrands, J.G.; Karnosky, D.F. 1996. Root growth and physiology of potted and field-grown trembling aspen exposed to tropospheric ozone. *Tree Physiology*. 16: 145-152.

Coleman, M.D.; Isebrands, J.G.; Dickson, R.E.; Karnosky, D.F. 1995. Photosynthetic productivity of aspen clones varying in sensitivity to tropospheric ozone. *Tree Physiology*. 15: 585-592.

David, Mark B.; Lawrence, Gregory B. 1996. Soil and soil solution chemistry under red spruce stands across the northeastern United States. *Soil Science*. 161 (5): 314-328.

Dickson, R.E.; Tomlinson, P.T. 1996. Oak growth, development and carbon metabolism in response to water stress. *Annals of Science and Forestry*. 53: 181-193.

Fernandez, Ivan J.; Lawrence, Gregory B.; Son, Yowhan. 1995. Soil-solution chemistry in a low-elevation spruce-fir ecosystem, Howland, Maine. *Water, Air and Soil Pollution*. 84: 129-145.

Fredericksen, T.S.; Joyce, B.J.; Skelly, J.M.; Steiner, K.C.; Kolb, T.E.; Kouterick, K.B. 1995. Physiology, morphology, and ozone uptake of leaves of black cherry seedlings, saplings, and canopy trees. *Environmental Pollution*. 90: 1-11.

Fredericksen, T.S.; Kolb, T.E.; Skelly, J.M.; Steiner, K.C.; Joyce, B.M.; Savage, J.E. 1996. Light environment alters ozone uptake per net photosynthetic rate in black cherry trees. *Tree Physiology*. 16: 485-490.

Fredericksen, T.S.; Steiner, K.C.; Skelly, J.M.; Joyce, B.J.; Kolb, T.E.; Kouterick, K.B. 1996. Diel and seasonal patterns of leaf gas exchange and xylem water potential of different-sized *Prunus serotina* Ehrh. trees. *Forest Science*. 42 (3): 1-7.

Gawel, James E.; Ahner, Beth A.; Friedland, Andrew J.; Morel, Francois M.M. 1996. Role for heavy metals in forest decline indicated by phytochelatin measurements. *Nature*. 381: 64-65.

- Griffith, Michael B.; Perry, Sue A.; Perry, William B. 1995. Leaf litter processing and exoenzyme production on leaves in streams of different pH. *Oecologia*. 102: 460-466.
- Hendrick, R.L.; Pregitzer, K.S. 1993. The dynamics of fine root length, biomass and nitrogen content in two northern hardwood ecosystems. *Canadian Journal of Forest Research*. 23 (12): 2507-2520.
- Hornbeck, J.W.; Smith, R.B. 1995. A water resources decision model for forest managers. In: *Caring for the forest: research in a changing world*. IUFRO 20th World Congress. 1995 August 6-12; Tampere, Finland: 32-33. Abstract.
- Lane, C.J.; Reed, D.D.; Mroz, G.D.; Liechty, H.O. 1996. Width of sugar maple (*Acer saccharum*, Marsh) tree rings as affected by climate. *Canadian Journal of Forest Research*. 23: 2370-2375.
- Lawrence, Gregory B.; David, Mark B. 1996. Chemical evaluation of soil-solution in acid forest soils. *Soil Science*. 161 (5): 298-313.
- Lawrence, Gregory B.; David, Mark B.; Shortle, Walter C. 1995. A new mechanism for calcium loss in forest-floor soils. *Nature*. 378: 162-165.
- Leak, William B.; Smith, Marie-Louise. 1996. Sixty years of management and natural disturbance in a New England forested landscape. *Forest Ecology and Management*. 81: 63-73.
- Liechty, Hal O.; Kuuseoks, Eimar; Mroz, Glenn D. 1995. Dissolved organic carbon in northern hardwood stands with differing acidic inputs and temperature regimes. *Journal of Environmental Quality*. 24: 927-933.
- MacDonald, N.W.; Burton, A.J.; Witter, J.A.; Richter, D.D. 1994. Sulfate absorption in forest soils of the Great Lakes region. *Soil Science Society of America Journal*. 58 (5): 1546-1555.
- MacDonald, N.W.; Zak, D.R.; Pregitzer, K.S. 1995. Temperature effects on kinetics of microbial respiration and net nitrogen and sulfur mineralization. *Soil Science Society of America Journal*. 59: 233-240.
- McHale, P.J.; Mitchell, M.J. 1996. Disturbance effects on soil solution chemistry due to heating cable installation. *Biology and Fertility of Soils*. 22: 40-44.
- McLaughlin, J.W.; Reed, D.D.; Bagley, S.T.; Jurgensen, M.F.; Mroz, G.D. 1994. Foliar amino acid accumulation as an indicator of ecosystem stress for first-year sugar maple seedlings. *Journal of Environmental Quality*. 23 (1): 154-161.
- McLaughlin, James W.; Fernandez, Ivan J.; Richards, Karen J. 1996. Atmospheric deposition to low-elevation spruce-fir forest, Maine, USA. *Journal of Environmental Quality*. 25 (2): 248-259.
- Melillo, J.M.; Borchers, J.; Chaney, J.; Fisher, H.; Fox, S.; Neilson, R.P. 1995. Vegetation ecosystem modeling and analysis project (VEMAP): comparing biogeography and biogeochemistry models in a continental-scale study of terrestrial ecosystem responses to climate change and CO<sub>2</sub> doubling. *Global Biogeochemical Cycles*. 9 (4): 407-437.
- Miller, Eric K.; Friedland, Andrew J. 1994. Lead migration in forest soils: response to changing atmospheric inputs. *Environmental Science & Technology*. 28 (4): 662-669.
- Minocha, Rakesh; Shortle, Walter C.; Coughlin, Jr., Daniel J.; Minocha, Subhash C. 1996. Effects of aluminum on growth, polyamine metabolism, and inorganic ions in suspension cultures of red spruce (*Picea rubens*). *Canadian Journal of Forest Research*. 26: 550-559.
- Ocamb, Cynthia M.; Juzwik, Jennifer. 1995. *Fusarium* species associated with rhizosphere soil and diseased roots of eastern white pine seedlings and associated nursery soil. *Canadian Journal of Plant Pathology*. 17: 325-330.
- Perala, Donald A.; Rollinger, Jeanette L. 1995. Comparison between soil and biomass carbon in adjacent hardwood and red pine forests. *World Resource Review*. 7 (2): 231-243.
- Potter, Brian E. 1996. Atmospheric mesoscale simulations of regional wildland fire episodes: looking for weather-related factors and scales of interaction. In: Hom, John; Birdsey, Richard; O'Brien, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program*, 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 197. Abstract.

- Pouyat, R.V.; Groffman, P.M.; Carreiro, M.M.; Bohlen, P.; Parmelee, R.W. 1996. Temperature and earthworm effects on C and N dynamics in oak stands along an urban-rural land use gradient. In: Hom, John; Birdsey, Richard; OBrian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program, 1995 March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 208. Abstract.
- Reed, D.D.; Pregitzer, K.S.; Liechty, H.O.; Burton, A.J.; Mroz, G.D. 1994. Productivity and growth efficiency in sugar maple forests. *Forest Ecology and Management*. 70: 319-327.
- Schaberg, P.G.; Shane, J.B.; Hawley, G.J.; Strimbeck, G.R.; DeHayes, D.H.; Cali, P.F. 1996. Physiological changes in red spruce seedlings during a simulated winter thaw. *Tree Physiology*. 16: 567-574.
- Schulze, E.D.; Schulze, W.; Kelliher, F.M.; Vyodskaya, N.N.; Ziegler, W.; Hollinger, D.Y. 1995. Aboveground biomass and nitrogen nutrition in a chronosequence of pristine Dahurian *Larix* stands in eastern Siberia. *Canadian Journal of Forest Research*. 25: 943-960.
- Shortle, W.C.; Smith, K.T.; Minocha, R.; Alexeyev, V.A. 1995. Similar patterns of change in stemwood calcium concentration in red spruce and Siberian fir. *Journal of Biogeography*. 22: 467-473.
- Smith, K.T.; Shortle, W.C.; Ostrofsky, W.D. 1995. Aluminum and calcium in fine root tips of red spruce collected from the forest floor. *Canadian Journal of Forest Research*. 25: 1237-1242.
- Stimbeck, G.R.; Schaberg, P.G.; DeHayes, D.H.; Shane, J.B.; Hawley, G.J. 1995. Midwinter dehardening of montane red spruce during a natural thaw. *Canadian Journal of Forest Research*. 25: 2040-2044.
- Tyree, Melvin T.; Davis, Stephen D.; Cochard, Herve. 1994. Biophysical perspectives of xylem evolution: Is there a tradeoff of hydraulic efficiency for vulnerability to dysfunction? *IAWA Journal*. 15 (4): 335-360.
- Tyree, Melvin T.; Patino, Sandra; Bennink, John; Alexander, John. 1995. Dynamic measurements of root hydraulic conductance using a high-pressure flowmeter in the laboratory and field. *Journal of Experimental Botany*. 46 (282): 83-94.
- Williams, David W.; Liebhold, Andrew M. 1995. Herbivorous insects and global change: potential changes in the spatial distribution of forest defoliator outbreaks. *Journal of Biogeography*. 22: 665-671.
- Williams, David W.; Liebhold, Andrew M. 1995. Influence of weather on the synchrony of gypsy moth (*Lepidoptera: Lymantriidae*) outbreaks in New England. *Environmental Entomology*. 24 (5): 987-995.

## Attainment

The Global Change Program has reached the culmination of the first 5-year research plan and has made significant progress in many areas: (1) Past and projected changes in climate, air pollution, and acid deposition can be estimated at regional to local scales. (2) Exposure to acidic clouds, common at high elevation in the Northeast, impairs the cold tolerance of red spruce foliage, predisposing it to winter injury. (3) White pine, trembling aspen, and yellow-poplar grown from seedlings to early maturity have demonstrated very different responses to elevated ozone levels, alone or in combination with elevated CO<sub>2</sub> levels. (4) Increased CO<sub>2</sub> and ozone change the chemical composition of foliage, which in turn has an impact on the resistance of foliage to insect attack and the nutritional value of the foliage for insect growth. (Continued in 1A)

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**Problem 1A                      Global Change Research (Continued)**  
**FY 96 Research Attainments**

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**Publications****Research Unit**

Hom, John L.; Krywult, Marek; Bytncrowicz, Andrzej; Pearcy, Kevin E. 1996. Internal uptake and assimilation of gaseous nitric acid by western forest tree species. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 82. Abstract.

**Extramural**

Anderson, P.D.; Tominson, P.T. 1996. Carbon assimilation response of northern red oak seedlings to elevated CO<sub>2</sub>, water stress and carbon sink activation state. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996, June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval. Abstract.

Anderson, Paul D.; Tomlinson, Patricia T. 1995. Carbon assimilation by multiple-flush northern red oak seedlings exposed to repeated drying cycles and elevated atmospheric carbon dioxide. In: Teclaw, Ronald M., ed. Sixth workshop on seedling physiology and growth problems in oak plantings; 1995 September 18-20; Rhinelander, WI. Gen. Tech. Rep. NC-182. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 2. Abstract.

Barrett, Hope R. 1996. Catalog of long-term research conducted within the USDA Forest Service, Northeastern Forest Experiment Station. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 226. Abstract.

Boerner, Ralph E.J.; Sutherland, Elaine Kennedy. 1995. Relative nitrogen mineralization and nitrification potentials in relation to soil chemistry in oak forest soils along a historical deposition gradient. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 167. Abstract.

Christiansen, Tim A.; Perry, Sue A.; Perry, William B. 1996. Microhabitat effects of litter temperature and moisture on forest-floor invertebrate communities. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 153. Abstract.

Coleman, M.D.; Dickson, R.E.; Isebrands, J.G. 1996. Root growth and respiration of aspen in response to ozone and elevated carbon dioxide. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 20. Abstract.

David, Mark B.; Lawrence, Gregory B.; Shortle, Walter C.; Bailey, Scott W. 1996. Calcium status of the forest floor in red spruce forests of the Northeastern U.S.—past, present and future. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 118. Abstract.

DeGaetano, Arthur T. 1996. Delineation of climate regions in the Northeastern United States. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 7. Abstract.

Fernandez, Ivan J.; Rustad, Lindsey E.; Simmons, Jeffrey A.; McLaughlin, James W. 1996. The Howland Integrated Forest Study (HIFS)—ecosystem research on atmospheric influences governing forest function. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 67. Abstract.

Goltz, S.M. 1996. Temporal and spatial trends of fluxes and concentrations of CO<sub>2</sub> above and within the canopy at Howland, Maine: preliminary results. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 229. Abstract.

Goltz, S.M.; Smith, James A. 1996. An energy balance model for forest canopies: a case study. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 228. Abstract.

Hallet, R.A.; Hornbeck, J.W. 1995. Cation depletion in New England forests. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 404-405.

Hallett, R.H.; Hornbeck, J.W. 1996. Cation depletion in New England forests. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 111. Abstract.

Heilman, Warren E. 1996. Synoptic circulation and temperature pattern during severe wildland fires. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 196. Abstract.

Hislop, J.E.; Hornbeck, J.W.; Hallett, R.A. 1995. Microwave digestion of forest soil and plant tissue samples. In: Quality of soil and plant analysis in view of sustainable agriculture and the environment: 1995 international symposium on soil and plant analysis; 1995 August 5-10; Wageningen, The Netherlands. [Place of publ. unknown]: [Publisher name unknown]: 43. Abstract.

Hislop, J.E.; Hallet, R.A.; Hornbeck, J.W. 1995. Microwave digestion of forest soil and plant tissue samples. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 396-397.

Isebrands, J.G.; Karnosky, D.F. 1996. Interacting effects of ozone and CO<sub>2</sub> on growth and physiological process in northern forest trees. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 22. Abstract.

Joyce, B.J.; Steiner, K.C.; Skelly, J.M. 1996. Water use in forest canopy black cherry trees and its relationship to leaf gas exchange and environment. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 41. Abstract.

Juzwik, J.; Rugg, D.J.; Menes, P.J.; Cease, K.R. 1995. Soil water management and Fusarium root rot in eastern white pine seedlings. In: 1995 annual international research conference on methyl alternatives and emissions reduction; 1995 November 6-8; San Diego, CA. [Place of publ. unknown]: [Publisher name unknown]: 76-1. Abstract.

Karnosky, D.F.; Gagnon, Z.; Dickson, R.E.; Pechter, P.; Coleman, M.; Kull, Olevi; Sober, Anu; Isebrands, J.G. 1996. Effects of ozone and CO<sub>2</sub> on the growth and physiology of aspen. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 21. Abstract.

- LeBlanc, David; Haack, Robert. 1996. Growth responses of white oak and black oak to drought stress across gradients of acid deposition and microclimate. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 183. Abstract.
- Lynch, James A.; Grimm, Jeffrey, W.; Corbett, Edward S. 1996. Enhancement of regional wet deposition estimates based on modeled precipitation inputs. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 8. Abstract.
- Nitao, James K.; Nair, Muraleedharan G.; Mattson, William J.; Herms, Daniel A.; Birr, Bruce A.; Coleman, Mark D.; Trier, Terry M.; Isebrands, J.G. 1996. Effects of elevated CO<sub>2</sub> and ozone on phenolic glycosides of trembling aspen. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 42. Abstract.
- Pardo, L.H.; Hornbeck, J.W. 1995. Natural abundance of <sup>15</sup>N as a tool for assessing nitrogen loss patterns from forest soils. *Bulletin of the Ecological Society of America*. 76(2). Abstract.
- Robert, Joy R.; Sharpe, William E. 1996. Long-term changes in the acidity of a DeKalb forest soil in the midregion of the Susquehanna River Watershed. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 131. Abstract.
- Schaberg, P.G.; Shane, J.B.; Hawley, G.J.; Strimbeck, G.R.; DeHayes, D.H.; Cali, P.F.; Donnelly, J.R. 1996. Thaw-induced changes in photosynthesis and cold hardiness of red spruce during winter. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 163. Abstract.
- Schier, George A.; McQuattie, Carolyn J. 1996. Effects of carbon dioxide enrichment on response of pitch pine grown at different nutrient levels to aluminum. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 31. Abstract.
- Strimbeck, G.R.; Vann, David R.; Johnson, Arthur H. 1996. Effects of calcium fertilization and acid mist on calcium concentration and cold tolerance of red spruce needles. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 10-12.
- Sutherland, Elaine Kennedy; Hale, Betsy J.; Hix, David M. 1996. Regeneration attributes of tree species in the central hardwoods type. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 215. Abstract.
- Sutherland, Elaine Kennedy; Yaussy, Daniel A.; Boerner, Ralph E.J. 1996. Mortality patterns in oak forests along a climatic and acid deposition gradient. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 168. Abstract.
- Tomlinson, P.T.; Anderson, P.D. 1995. Elevated CO<sub>2</sub> compensates for water stress in red oak. *Plant Physiology*. 108(2): 36. Abstract.
- Tomlinson, P.T.; Anderson, P.D. 1996. Distribution of biomass and current photosynthate in northern red oak under elevated CO<sub>2</sub> and water stress. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval. Abstract.

Tomlinson, Patricia T.; Anderson, Paul D. 1996. Elevated CO<sub>2</sub> compensates for water stress in northern red oak. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 32. Abstract.

Verry, Elon S. 1996. Methane evolution from Minnesota peatlands. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 165. Abstract.

White, Edwin H.; Buxbaum, Charles A.Z.; Nowak, Christopher A. 1996. Nutrient cycling in aggrading forests: 50 years of research at Pack Forest, New York. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program. 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 166. Abstract.

Williams, David W.; Liebhold, Andrew M. 1996. Herbivorous insects and climate change: potential changes in the spatial distribution of forest defoliator outbreaks. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program. 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 216. Abstract.

Yarie, John; Hammond, Tim. 1996. Carbon balance of the Alaskan boreal forest. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program. 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 227. Abstract.

Attainment

(Continued) (5) Investigations on larch have shown how rapidly conifers can change their genetic makeup when faced with changes in the environment. (6) Long-term studies at a commercial spruce-fir forest in Howland, Maine and at a high-elevation spruce-fir forest on Whiteface Mountain, New York, have shown that most of the nitrogen deposited in rainfall and cloud droplets is retained in the ecosystem. Some sites are beginning to show signs of nitrogen saturation which could lead to reduced growth and increased nitrate pollution of fresh and marine water systems. (7) Several long-term studies in the Adirondack Mountains of New York and the White Mountains of New Hampshire have documented a substantial decline in calcium in the organic soil layers of red spruce forests. This is a likely cause of decreased productivity and decline/dieback of red spruce. (continued in 1B)

## Problem 1B

Global Change Research (Continued)  
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## Publications

## Research Unit

Birdsey, Richard A.; Hom, John L.; Emery, Marla. 1996. The Northern Global Change Research Program. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 1-6.

Heath, Linda S.; Birdsey, Richard A. 1996. Carbon sequestration on nonindustrial private forestlands in the US. In: Baughman, Melvin, J., ed. Proceedings of symposium on non-industrial private forests: learning from the past, prospects for the future; 1996 February 18-20; Washington, DC. St. Paul, MN: University of Minnesota, Minnesota Extension Service: 326-333.

Heath, Linda S.; Birdsey, Richard A.; Row, Clark; Plantinga, Andrew J. 1996. Carbon pools and fluxes in U.S. forest products. In: Apps, Michael J.; Price, David T., comps., eds. Forest ecosystems, forest management and the global carbon cycle. Berlin, Germany: Springer-Verlag: 271-278.

## Extramural

Bell, J.C.; Grigal, D.F.; Bates, P.C.; Butler, C.A. 1996. Spatial patterns in carbon storage in a Lake States' landscape. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 198-202.

Fast, Jerome D.; Heilman, W.E. 1996. The effect of regional-scale soil-moisture deficits on mesoscale atmospheric dynamics that influence fire severity. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & aerobiology; 1996 January 28-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 280-283.

Greenwood, Michael S.; Hutchinson, Keith W. 1996. Genetic aftereffects of increased temperature in Larix. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 56-62.

Heilman, Warren E. 1996. Overview of current research on atmospheric interactions with wild-land fires. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 192-195.

Heilman, Warren E.; Zasada, John C.; Teclaw, Ronald M.; Buckley, David S. 1996. Harvesting effects on the microclimate of northern hardwood forests in the upper Great Lakes region. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & Aerobiology; 1996 January 28-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 397-400.

Hermes, Daniel A.; Mattson, William J.; Karowe, David N.; Coleman, Mark D.; Trier, Terry M.; Birr, Bruce A. 1996. Variable performance of outbreak defoliators on aspen clones exposed to elevated CO<sub>2</sub> and O<sub>3</sub>. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 43-55.

Host, George E.; Theseira, Gary W.; Isebrands, J.G. 1996. Modeling impacts of CO<sub>2</sub> ozone, and climate change on tree growth. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 33-37.

Iverson, Louis R.; Prasad, Anantha M.G.; Scott, Charles T. 1996. Preparation of forest inventory and analysis (FIA) and state soil geographic data base (STATSGO) data for global change research in the Eastern United States. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 209-214.

Iverson, Louis R.; Scott, Charles T.; Dale, Martin E.; Prasad, Anantha. 1995. Development of an integrated moisture index for predicting species composition. In: Kohn, Michael; Gertner, George Z., eds. Caring for the forest: research in a changing world. Statistics, mathematics and computers. Proceedings of the meeting of IUFRO, XX World Congress; 1995 August 6-12; Tampere, Finland. Birmensdorf, Switzerland: Swiss Federal Institute for Forest, Snow and Landscape Research: 101-116.

Johnson, A.H.; Strimbeck, G.R. 1996. Thirty-three year changes in above- and below-ground biomass in northern hardwood stands in Vermont. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 169-174.

Juzwik, Jennifer; Menes, Peter J.; Rygg, David J. 1993. Soil moisture and Fusarium root rot of white pine seedlings. In: Proceeding of Northeastern and Intermountain Forest and Conservation Nursery Associations; 1993 August 2-5, 1993; St. Louis, MO. Gen. Tech. Rep. RM-243. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 85-90.

Kaufman, Michael G.; Strand, R. Malcolm; Kubiske, Mark E.; Mattson, William J.; Herms, Daniel A.; Walker, Edward D. 1996. Effects of elevated CO<sub>2</sub> and shade on the decomposition of senesced tree foliage: impacts on microbial activity. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 89-100.

Kelliher, F.M.; Hollinger, D.Y.; Schulze, E.D.; Vygodskaya, N.N.; Byers, J.N.; Hunt, J.E. 1996. Evaporation from an eastern Siberian larch forest. In: Proceedings of the international symposium on forest hydrology; 1994 October; Tokyo, Japan. [Place of publ. unknown]: [Publisher name unknown]: 123-130.

Kirschbaum, M.U.F.; Fischlin, A.; Cannell, M.G.R.; Cruz, P.; Galinski, W.; Neilson, R.P. 1996. Climate change impacts on forests. In: Watson, R.T.; Zinyowera, M.C.; Moss, R.H., comps., eds. Climate change 1995. Impacts, adaptations and mitigation of climate change: scientific-technical analyses. Cambridge, UK: Cambridge University Press: 97-122.

Lawrence, Gregory B.; David, Mark B.; Shortle, Walter C. 1996. Aluminum mobilization and calcium depletion in the forest floor of red spruce. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 112-117.

McHale, Patrick J.; Mitchell, Myron J.; Raynal, Dudley J.; Bowles, Francis P. 1996. Increasing soil temperature in a northern hardwood forest: effects on elemental dynamics and primary productivity. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 146-152.

McLaughlin, James W.; Fernandez, Ivan J.; Goltz, Stewart M.; Rustad, Lindsey E.; Zibilske, Larry. 1996. Biogeochemical cycling of carbon, nitrogen, and sulfur at the Howland Integrated Forest study site, Howland, Maine. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 68-76.

Minocha, Rakesh; Shortle, Walter C.; Lawrence, Gregory B.; David, Mark B.; Minocha, Subhash C. 1996. Putrescine: a marker of stress in red spruce trees. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 119-130.

- Ollinger, Scott V.; Aber, John D.; Reich, Peter B. 1996. Predicting the effects of tropospheric ozone on forest productivity in the northeastern U.S. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 217-224.
- Pell, Eva J.; Brendley, Bryan W.; Sin, Judith P. 1996. Ozone-induced accelerated foliar senescence: implications for toxicity and compensation. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 13-19.
- Pregitzer, Kurt S.; Reed, David D.; Mroz, Glenn D.; Burton, Andrew J.; Witter, John A.; Zak, Donald A. 1996. Climatic and pollution influences on ecosystem processes in northern hardwood forests. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 83-88.
- Rebbeck, Joanne. 1996. The chronic response of yellow-poplar and eastern white pine to ozone and elevated carbon dioxide: three-year summary. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 23-30.
- Reed, D.D.; Jones, E.A.; Densanker, P.V. 1994. Potential impact of projected climate change scenarios on individual tree species in central North America. In: Proceedings of the 13th international congress of biometeorology, part 2, volume 1; 1993 September 12-18; Calgary, AB. [Place of Publ. unknown]: [Publisher name unknown]: 910-919.
- Reed, D.D.; Mroz, G.D.; Liechty, H.O.; Pregitzer, K.S.; Burton, A.J.; Zak, D.R. 1996. Studying the effects of air pollution on forests along exposure gradients: experience in the United States and opportunities for cooperation. In: Proceedings of the conference on climate and atmospheric deposition studies in forests; 1992 October 6-9; Nieborow, Poland. [Place of publ. unknown]: Polish Academy of Sciences: 109-115.
- Rollinger, Jeanette L.; Strong, Terry F. 1996. Carbon storage in managed forests of the northern Great Lakes states. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 203-207.
- Rowe, Jacquelyn M.; Perry, William B.; Perry, Sue A. 1996. Leaf litter processing in West Virginia mountain streams: effects of temperature and stream chemistry. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 157-160.
- Rustad, Lindsey E.; Fernandez, Ivan J.; Arnold, Stephanie. 1996. Experimental soil warming effect on C, N, and major element cycling in a low elevation spruce-fir forest soil. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 132-139.
- Schwartz, Mark W. 1996. Assessing the ability of plants to respond to climatic change through distribution shifts. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 184-191.
- Simmons, Jeffrey A.; Fernandez, Ivan J.; Briggs, Russell D. 1996. Soil respiration and net N mineralization along a climate gradient in Maine. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995, March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 140-145.

- Smith, Kevin T.; Shortle, Walter C.; Minocha, Rakesh; Alexeyev, Vladislav A. 1996. Dynamics of calcium concentration in stemwood of red spruce and Siberian fir. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 230-238.
- Solada, Steven W.; Perry, Sue A.; Perry, William B. 1996. Leaf litter decomposition and elemental change in three Appalachian mountain streams of different pH. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 161-164.
- Solomon, Dale S.; Leak, William B. 1996. Evaluation of methodology for detecting/predicting migration of forest species. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 175-182.
- Strand, R. Malcolm; Herms, Daniel A.; Kaufman, Michael G.; Kubiske, Mark E.; Mattson, William J.; Walker, Edward D. 1996. Effects of elevated CO<sub>2</sub> and shade on the decomposition of senesced tree foliage: impacts on the growth and survival of treehole mosquitoes. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 101-110.
- Tyree, Melvin T. 1994. Ion transport across leaf cuticles: concepts and mechanisms. In: Percy, K.E.; Cape, J.N., comps., eds. Air pollutants and the leaf cuticle. Heidelberg, Germany: Springer-Verlag: 55-65.
- Tyree, Melvin T.; Ewers, Frank W. 1996. Hydraulic architecture of woody tropical plants. In: Mulkey, Stephen S.; Chazdon, Robin L.; Smith, Alan P., comps., eds. Tropical forest plant ecophysiology. New York, NY: Chapman & Hall: 217-243.
- Van Sambeek, J.W.; Preece, John E.; Navarrete, Nadia E.; Rink, George. 1996. Physiological and genotypic responses of central hardwood species to allelochemicals, other stresses, and their interactions. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 63-66.
- Yausy, Daniel A.; Sutherland, Elaine Kennedy; Hale, Betsy J. 1996. Rule-based individual-tree regeneration model for forest simulators. In: Skovsgaard, J.P.; Johannsen, V.K., eds. Modelling regeneration success and early growth of forest stands: proceedings from the IUFRO conference; 1996 June 10-13; Copenhagen, Denmark. Horsholm, Denmark: Danish Forest and Landscape Research Institute: 176-182.

#### Attainment

(Continued) (8) Warmer temperatures have been shown to affect carbon and nitrogen dynamics in northern forest soils which in turn affects productivity, species composition, and carbon sequestration. (9) Using average ozone exposures recorded from 1987 to 1992, it was estimated that annual forest productivity was reduced from 2 to 17 percent, with the greatest reductions in southern New York and New England. (10) Increases in biomass on U.S. forest lands over the last 40 years have added 281 million metric tons per year of stored carbon, enough to offset 25 percent of U.S. emissions for the period. Projections show additional increases in carbon storage, but at a slower rate. (continued on 1C)

## Problem 1C

Global Change Research (Continued)  
FY 96 Research Attainments

## Publications

## Research Unit

Birdsey, R.A.; Heath, L.S. 1995. Carbon changes in U.S. forests. In: Joyce, Linda S., ed. Productivity of America's forests and climate change. Gen. Tech. Rep. RM-GTR-271. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 56-70.

Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. 1996. Proceedings, 1995 meeting of the Northern Global Change Program. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 238.

## Cooperative

Joyce, Linda A.; Mills, John R.; Heath, Linda S.; McGuire, A.D.; Haynes, Richard W.; Birdsey, Richard A. 1995. Forest sector impacts from changes in forest productivity under climate change. *Journal of Biogeography*. 22: 703-713.

## Extramural

Boerner, Ralph E.J.; Sutherland, Elaine Kennedy. 1995. Nitrogen mineralization and nitrification potentials along a historical atmospheric deposition gradient. In: Gottschalk, Kurt W.; Fosbroke, Sandra L.C., eds. Proceedings, 10th central hardwood forest conference; 1995 March 5-8; Morgantown, WV. Gen. Tech. Rep. NE-197. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 523-533.

Engstrom, Erik S.; Meegan, Sean K.; Perry, Sue A.; Perry, William B. 1996. Effects of acidic precipitation on leaf decomposition rates, microbial biomass, and leaf pack macroinvertebrates in six streams on the Allegheny Plateau of West Virginia. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 154-156.

Fredericksen, Todd S.; Skelly, John M.; Steiner, Kim C.; Kolb, Thomas E. 1996. Ozone exposure, uptake, and response of different-sized black cherry trees. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 38-40.

Frey, Serita D. 1996. Workshop on effects of management on forest soil; a report. Gen. Tech. Rep. NE-217. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 13.

Friedland, Andrew J.; Miller, Eric K. 1996. Elemental cycling response of an Adirondack subalpine spruce-fir forest to atmospheric and environmental change. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 77-81.

Hawley, G.J.; DeHayes, D.H. 1996. Impact of natural thinning on the genetic diversity of *Pinus banksiana* populations. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 86. Abstract.

Hawley, G.J.; Schaberg, P.E.; DeHayes, D.H.; Strimbeck, G.R.; Cumming, J.R. 1996. Perturbations to membrane calcium: a mechanism for global change-induced cold injury. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 143. Abstract.

Hendrick, Ronald L.; Pregitzer, Kurt S. 1996. Temporal and depth-related patterns of fine root dynamics in northern hardwood forests. *Journal of Ecology*. 84: 167-176.

Hollinger, D.Y.; Kelliher, F.M.; Byers, J.N.; Hunt, J.E.; McSeveny, T.M.; Weir, P.L. 1994. Carbon dioxide exchange between an undisturbed old-growth temperate forest and the atmosphere. *Ecology*. 75 (1): 134-150.

Hollinger, D.Y.; Kelliher, F.M.; Schulze, E.D.; Kostner, B.M.M. 1994. Coupling of tree transpiration to atmospheric turbulence. *Nature*. 371: 60-62.

Hollinger, D.Y.; Kelliher, F.M.; Schulze, E.D.; Vygodskaya, N.N.; Varlagin, A.; Milukova, I. 1995. Initial assessment of multi-scale measures of CO<sub>2</sub> and H<sub>2</sub>O flux in the Siberian taiga. *Journal of Biogeography*. 22: 425-431.

Hollinger, D.Y.; Maclaren, J.P.; Beets, P.N.; Turland, J. 1993. Carbon sequestration by New Zealand's plantation forests. *New Zealand Journal of Forestry Science*. 23 (2): 194-208.

Hornbeck, J.W.; Bailey, S.W.; Buso, D.C.; Shanley, J.B. 1995. Regional representation of 3 experimental watersheds in New England. In: proceedings, 1995 fall meeting of American Geophysical Union. EOS Supplement 76(48): 261. Abstract.

Iverson, Louis R.; Hutchinson, Todd F.; Sutherland, Steve; Windus, Jennifer. 1995. Integrated moisture index as a predictor of vascular plant species composition and richness in southeast Ohio oak forests. *Bulletin of the Ecological Society of America* 76(2). Abstract.

Jagels, R.; Hornbeck, J.; Marden, S. 1994. Drought and cold stress-induced morphometric changes in tree rings of red spruce. *Tech. Bull.* 159. Orono, ME: Maine Agricultural and Forest Experiment Station. 19.

Jones, Elizabeth A.; Reed, David D.; Desanker, Paul V. 1994. Ecological implications of projected climate change scenarios in forest ecosystems of central North America. *Agricultural and Forest Meteorology*. 72: 31-46.

Jones, W.; Smith, Robert B. 1995. A water resources decision model for forest managers. In: Kohn, Michael; Gertner, George Z., eds. *Caring for the forest: research in a changing world. Statistics, mathematics and computers. Proceedings of the meeting of IUFRO XX World Congress; 1995 August 6-12; Tempere, Finland.* Birmensdorf, Switzerland: Swiss Federal Institute for Forest, Snow and Landscape Research. Abstract.

Karnosky, D.F.; Gagnon, Z.E.; Dickson, R.E.; Coleman, M.D.; Lee, E.H.; Isebrands, J.G. 1996. Changes in growth, leaf abscission, and biomass associated with seasonal tropospheric ozone exposures of *Populus tremuloides* clones and seedlings. *Canadian Journal of Forest Research*. 26: 23-37.

Kittle, T.G.F.; Rosenbloom, N.A.; Painter, T.H.; Schimel, D.S.; Melillo, J.M.; Neilson, R.P. 1995. The VEMAP integrated database for modeling United States ecosystem/vegetation sensitivity to climate change. *Journal of Biogeography*. 22: 857-862.

Kull, O.; Sober, A.; Coleman, M.D.; Dickson, R.E.; Isebrands, J.G.; Gagnon, Z. 1996. Photosynthetic responses of aspen clones to simultaneous exposures of ozone and CO<sub>2</sub>. *Canadian Journal of Forest Research*. 26: 639-649.

Solomon, Dale S.; Leak, William B. 1994. Migration of tree species of New England based on elevational and regional analyses. *Res. Pap. NE-688*. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9.

## Attainment

(Continued) (11) Results from the U.S. Carbon Budget Model (FORCARB) have influenced national decisions regarding the effects of alternate policies for offsetting greenhouse gas emissions through forestry actions as part of the President's Climate Change Action Plan.

**Northeastern Forest Experiment Station  
Forest Protection Research  
Research Work Unit 4501**

**Forest Insect Biology and Biocontrol  
Shields, Kathleen S., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
2. Genetics, physiology and ecology to enhance biorational methods to manage gypsy moth	FPR	260	1.1	8		5
3. Reduce likelihood of establishment of Asian race of gypsy moth in North America	FPR	500	2.7	7		2
5. Implement a biological control program to reduce populations of hemlock woolly adelgid	FPR	240	1.2	2		

**Problem 2****Genetics, physiology and ecology to enhance biorational methods to manage gypsy moth  
FY 96 Research Attainments****Publications****Research Unit**

Butt, Tariq M.; Shields, Kathleen S. 1996. The structure and behavior of gypsy moth (*Lymantria dispar*) hemocytes. *Journal of Invertebrate Pathology*. 68: 1-14.

Keena, Melody A.; ODell, Thomas M.; Tanner, John A. 1995. Effects of diet ingredient source and preparation method on larval development of laboratory-reared gypsy moth (Lepidoptera: Lymantriidae). *Annals of the Entomological Society of America*. 88 (5): 672-679.

Keena, Melody A.; ODell, Thomas M.; Tanner, John A. 1995. Phenotypic response of two successive gypsy moth (Lepidoptera: Lymantriidae) generations to environment and diet in the laboratory. *Annals of the Entomological Society of America*. 88 (5): 680-689.

ODell, Thomas M.; Mikus, David R.; Keena, Melody A.; Willis, Raymond B. 1995. Gypsy moth nutritional ecology: importance of iron bioavailability during various larval growth periods on the development and survival of their progeny. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213*. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 104. Abstract.

Shields, Kathleen S.; Podgwaite, John D. 1995. Gypsy moth larval peritrophic membrane: surface structure and pathology. In: Greenplate, John, ed. *Transitions: 1995 annual meeting of the Entomological Society of America; Lanham, MD. Lanham, MD: Entomological Society of America: 43*. Abstract.

Shields, Kathleen S.; Podgwaite, John D. 1995. Peritrophic membrane: site of action for LdMNPV/optical brightener in gypsy moth larvae. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213*. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 112. Abstract.

Willis, Raymond B.; Montgomery, Michael E.; ODell, Thomas M. 1995. Bioavailable iron: importance of amorphous compared to crystalline ferric phosphate. In: 109th AOAC international annual meeting & exposition; 1995 September 17-21; Nashville, TN. Arlington, VA: American Association of Analytical Chemists: 63-64. Abstract.

(No editors or compilers are provided in the proceedings book.)

Willis, Raymond B.; Montgomery, Michael E.; Allen, Philip R. 1996. Improved method for manual, colorimetric determination of total Kjeldahl nitrogen using salicylate. *Agricultural and Food Chemistry*. 44 (7): 1804-1807.

**Cooperative**

Dubois, Normand R.; Keena, Melody A. 1995. Analysis of the effect of repeated treatments of *Bacillus thuringiensis* on gypsy moth populations. In: *Program and abstracts: SIP 28th annual meeting; 1995 July 16-21; Ithaca, NY. Ithaca, NY: Cornell University: 16*. Abstract.

Dubois, Normand R.; Keena, Melody A.; Huntley, Pamela; Newman, DeAdra. 1995. Effect of repeated treatments of *Bacillus thuringiensis* against gypsy moth populations: initial survey. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213*. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 64. Abstract.

Hastings, F.L.; Hain, F.P.; Smith, H.R.; ODell, T.M. 1995. Natural enemies of the gypsy moth at the leading edge of its invasion into the southern U.S. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213*. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 76. Abstract.

Hastings, F.L.; Hain, F.P.; Smith, H.R.; Odell, T.M.; Cook, S.P. 1995. Natural enemies of the gypsy moth at the leading edge of the invasion into the southern U.S. In: Hain, Fred P.; Salom, Scott M.; Ravlin, William F.; Payne, Thomas L.; Raffa, Kenneth F., eds. Behavior, population dynamics and control of forest insects. Proceedings of the IUFRO joint conference; 1994 February 6-11; Maui, HI. Wooster, OH: The Ohio State University, Ohio Agricultural Research and Development Center:

Schaefer, Paul E.; Shields, Kathleen S.; Aldrich, Jeffrey R. 1995. Larval gypsy moth dorsal abdominal glands: histology, ultrastructure and preliminary chemical identification of exudate. In: Fosbroke, Sandra L.C.; Gottschalk, K.W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 110-111. Abstract.

## Attainment

Studies on the mode of action of microbial pathogens of gypsy moth have elucidated the structure and behavior of hemocytes, which are among the first cells in the insect to replicate virus. The structural integrity of the peritrophic membrane which lines the insect's gut was determined to be unaffected by virus, but it deteriorates and ultimately disintegrates when a fluorescent brightener is added to the formulation, resulting in increased virus pathogenicity. No evidence of resistance to Bt was found among wild populations of gypsy moth, regardless of geographical location or Bt treatment history. The natural enemy complex was evaluated at the leading edge of the gypsy moth invasion into the southern U.S. Establishing differences in biodiversity as the gypsy moth moves southward could have important implications in forest management. A series of studies documented variables affecting performance of gypsy moth, including environment, substrains, and diet. Expression of slow, asynchronous development of larvae was found to result from a dietary problem and sensitivity varies within populations. Mineral components were determined to affect larval development. These findings were essential for continued production of insects for research and biological control products, and provide insight into new strategies for managing gypsy moth populations.

Problem 3	Reduce likelihood of establishment of Asian race of gypsy moth in North America
	FY 96 Research Attainments

Publications

Research Unit

Keena, Melody A.; Grinberg, Phyllis S.; Wallner, William E. 1995. Asian gypsy moth genetics: biological consequences of hybridization. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 80. Abstract.

Keena, Melody A. 1996. Comparison of hatch *Lymantria dispar* (Lepidoptera: Lymantriidae) eggs from Russia and the United States after exposure to different temperatures and durations of low temperature. *Annals of the Entomological Society of America*. 89 (4): 564-572.

Montgomery, Michael E. 1996. Suitability of hosts for Asian and North American populations of the gypsy moth. In: Wilson, Jill; Schultz, Mark, comp. Proceedings, 4th international western forest insect and disease work conference; 1994 March 7-10; Albuquerque, NM. U.S. Department of Agriculture, Forest Service, Southwest Region, Forest Pest Management: 74.

Montgomery, Michael E.; Baranchikov, Yuri N. 1995. Comparison of performance on several tree species of gypsy moth from Central Asia, North America, and their hybrids. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 97. Abstract.

Wallner, William E. 1995. Asian/Siberian/European gypsy moth research: are further efforts necessary? In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 120. Abstract.

Wallner, William E. 1996. Biological pollutants and U.S. forests: whose problem—who pays? In: Proceedings, National Plant Board 69th annual meeting; 1995 August 13-16; San Diego, CA. [Place of publ. unknown]: California Department of Agriculture: 233-258.

Wallner, William E. 1996. Invasion of the tree snatchers. *American Nurseryman*. 183 (6): 28-30.

Cooperative

Baranchikov, Yuri; Vshivkova, Tamara; Montgomery, Michael. 1995. Suitability of foreign tree species for *Lymantria mathura* Moore. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 49. Abstract.

Baranchikov, Yuri N.; Nikitenko, Galina N.; Montgomery, Michael E. 1995. The Russian and Ukrainian literature on the gypsy moth. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 48. Abstract.

**Attainment**

Research studies determined the Asian race of the gypsy moth (AGM) exhibits substantial variation in egg hatch in response to cold temperatures, and therefore adaptation to a wide range of climates is possible. In addition, based on studies utilizing several North American tree species, the AGM can be expected to survive and grow better than the North American gypsy moth (NAGM), and hybrids of the AGM and NAGM can be expected to perform better than the NAGM. Hybrid larvae grow faster than do NAGM larvae, and after 2 generations of hybridization female moths are capable of flight. The presence of hybrids in North America could substantially increase the ability of the gypsy moth to spread (by female flight) and could alter when life stages are present. To assist in conducting research on AGM, a bibliography has been assembled on the gypsy moth in the former territories of the USSR, which includes information needed to locate the original publication.

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**Problem 5**

**Implement a biological control program to reduce populations of hemlock woolly adelgid  
FY 96 Research Attainments**

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**Publications****Research Unit**

Lyon, S.M.; Montgomery, M.E. 1995. *Scymnus* (*Pullus*) *suturalis* Thunberg (Coleoptera: Coccinellidae): new locality records, and a report of feeding on hemlock woolly adelgid, *Adelges tsugae* Annand (Homoptera: Adelgidae). *Coleopterists Bulletin*. 49 (2): 118.

(Senior author was employed as a temporary technician at the time the research was conducted.)

Young, Rebecca F.; Shields, Kathleen S.; Berlyn, Graeme P. 1995. Hemlock woolly adelgid (Homoptera: Adelgidae): stylet bundle insertion and feeding sites. *Annals of the Entomological Society of America*. 88 (6): 827-835.

(Senior author was employed as a temporary technician at the time the research was conducted.)

**Attainment**

A coccinellid beetle, *Scymnus suturalis*, presently found in North America, was determined to be a predator of the hemlock woolly adelgid (HWA). Adult beetles feed on HWA eggs and also consume all other life stages of the pest. Beetle larvae feed on HWA eggs and nymphs. Whether this predator can effectively reduce populations of the HWA remains to be determined. Studies of the feeding mechanisms of the HWA determined the site on the host plant that is penetrated by the insect's mouthparts, the pathway traveled by the feeding stylet, and the ultimate feeding site within the plant. This pest does not feed on sap; it feeds on storage cells, the parenchyma cells which comprise the xylem rays. This suggests that the intense impact of the HWA on eastern hemlock trees may be caused not only by feeding, but could be due to other factors such as possible toxic effect, or altered host plant response to environmental conditions.

**Northeastern Forest Experiment Station  
Forest Protection Research  
Research Work Unit 4502**

**Pathology and Microbial Control of Insects Defoliating Eastern Forest Trees  
McManus, Michael L., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Develop the technology needed to optimize use of Bt to protect forests from defoliating insects	FPR	235	1.2	3	1	1
2. Improve production, enhance activity, and optimize appli. of Gypchek against gypsy moth	FPR	353	1.0	2	2	2
3. Effect of Bt application on distribution and abundance of non-target Lepidoptera in forests	FPR	118	1.0	1		1
4. Introduce/establish exotic pathogens i.e. microsporidia to enhance natural control of GM	FPR	78	.7	1	2	3
M1. Develop and evaluate integrated pest management (IPM) strategies to manage the gypsy moth	FPR	0	.1	1	5	3

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<b>Problem 1</b>	<b>Develop the technology needed to optimize use of Bt to protect forests from defoliating insects</b>
	<b>FY 96 Research Attainments</b>

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**Publications****Research Unit**

Dubois, Normand R. 1993. Review of "Bacillus thuringiensis, an environmental biopesticide theory and practice." In: Entwistle Philip W.; Cory Jenny S.; Baily Mark J.; Higgs, Stephen; Wiley, John & Sons, eds. Entomological Society of America. Vol. 28 (I) March 1996. 20-21. Book Review.

Dubois, Normand R.; Keena, Melody A.; Huntley, Pamela; Newman, DeAdra. 1995. Effect of repeated treatments of Bacillus thuringiensis against gypsy moth populations: initial survey. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 64. Abstract.

Dubois, Normand R.; Dean, Donald H. 1995. Synergism between CryIA insecticidal crystal proteins and spores of Bacillus thuringiensis, other bacterial spores, and vegetative cells against *Lymantria dispar* (Lepidoptera: Lymantriidae) larvae. Journal of Environmental Entomology. 24 (6): 1741-1747.

**Cooperative**

Lee, Mi Kyong; Curtiss, A.; Dubois, N.R.; Dean, D.H. 1995. Mixing experiments between CRYIAA and CRYIAC insecticidal crystal proteins suggest oligomerization of toxins. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 81. Abstract.

**Extramural**

Novotny, Julius. 1995. The use of Bt for Foray 48 FC (Novo Nordisk) for control of gypsy moth in the forests of the Slovak Republic. In: Fosbroke, Sandra, L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 101. Abstract.

**Attainment**

There is major concern that development of resistance to *Bacillus thuringiensis* (Bt) in insect populations could become significant and widespread. The potential for development of resistance in gypsy moth (GM) populations that are repeatedly treated with Bt need to be evaluated. Results to date show that a) untreated wild populations do not differ in their susceptibility to Bt from comparable populations that were repeatedly treated 3 to 6 times; b) neither do their lab reared second generation progenies differ from each other; c) progenies selected from an LC75 dose do not differ in their susceptibility to Bt from unselected progenies. Initial analysis had shown that the asian strain of the gypsy moth, introduced through Vancouver B.C. does not differ significantly to Bt from the North American strain. More recent analysis of 6 european and 7 asian populations showed that there was a significant difference in their susceptibility to Bt. Relative to the laboratory standard gypsy moth strain (NJSS40) populations for Lithuania were 5 times more susceptible and populations from the Russian Black Lake were 4 times less susceptible than the NJSS40. These differences persisted with second generation progenies. Preliminary analysis indicates that the siberian silk moth is susceptible to Bt. There is indication that the Browntail moth may also be susceptible, however, difficulties in stabilizing the pest to a laboratory environment made the completion of the analysis more difficult. Electrophysiological studies (Voltage/current clamp) on the effect of Bt toxins in the midgut membranes of gypsy moth, siberian silkmoth and browntail moths are in progress.

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**Problem 2****Improve production, enhance activity, and optimize appli. of Gypchek against gypsy moth  
FY 96 Research Attainments****Publications****Research Unit**

D'Amico, Vincent; Elkinton, Joseph S.; Wood, H. Alan; Podgwaite, John D.; McManus, Michael L.; Slavicek, James; Burand, John P. 1995. A field test of genetically engineered gypsy moth NPV. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 61. Abstract.

Podgwaite, J.D.; Reardon, R.C. 1995. Production and formulation of Gypchek. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 106. Abstract.

**Cooperative**

Shields, Kathleen S.; Podgwaite, John D. 1995. Peritrophic membrane: site of action for LdMNPV/optical brightener in gypsy moth larvae. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 112. Abstract.

Webb, R.E.; Dill, N.H.; Podgwaite, J.D.; Shapiro, M.; Ridgway, J.L.; Vaughn, J.L. 1994. Control of third and fourth instar gypsy moth (Lepidoptera: Lymantriidae) with Gypchek combined with a stilbene disulfonic acid additive on individual shade trees. *Journal of Entomological Science*. 29 (1): 82-91.

**Extramural**

D'Amico, Vincent; Elkinton, Joseph S. 1995. Rainfall effects on transmission of gypsy moth (Lepidoptera: Lymantriidae) nuclear polyhedrosis virus. *Environmental Entomology*. 24 (5): 1144-1149.

D'Amico, Vincent; Elkinton, Joseph S.; Dwyer, Greg; Burand, John P. 1996. Virus transmission in gypsy moths is not a simple mass action process. *Ecology*. 77 (1): 201-206.

**Attainment**

In bioassays, the viral pesticide Gypchek was found to be more virulent against Asian gypsy moth larvae from the Russian far east, but somewhat less virulent against gypsy moth larvae from eastern european countries, when compared to the standard New Jersey laboratory strain. This information is critical for establishing efficacious doses of Gypchek for either suppression or eradication of exotic strains that may enter the U.S. Further, there is a continuing interest in the use of Gypchek in foreign countries in which Asian strains are now, or likely to be established. RWU personnel continue to produce Gypchek in the absence of a commercial partner; in 1996 more than 1,200 acres were treated in suppression and eradication programs. Bioassays of a genetically distinct viral variant derived from Gypchek have indicated that it will be cost-effective for in-vivo production and adaptable to large-scale in-vitro production. The variant was produced in vitro, formulated by American Cyanamid Co., and ground field-tested in collaboration with ARS partners. Results of the ground test indicated that the commercially formulated strain, when mixed with a viral-enhancing agent, was as effective as Gypchek in reducing larval populations and in protecting foliage. A single application of a ready-to-use Gypchek spray adjuvant, was pilot tested and found to be as effective as the previously recommended double application. Results of Gypchek studies have been reported to various work conferences, research forums and scientific meetings. This microbial pesticide is extremely compatible with forest protection and ecosystem management initiatives because of its efficacy, specificity and safety against non-target organisms.

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**Problem 3**                      **Effect of Bt application on distribution and abundance of non-target  
Lepidoptera in forests**  
**FY 96 Research Attainments**

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**Publications**

**Research Unit**                      Carter, Jane L.; Peacock, John W.; Neale, Laura; Talley, Steve E. 1995. A field assessment of the effects of *Bacillus thuringiensis* on non-target Lepidoptera: light trap sampling. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 59. Abstract.

**Cooperative**                      Wagner, David L.; Henry Julie J.; Peacock, John W.; McManus, Michael L.; Reardon, Richard C. 1995. Common caterpillars of eastern deciduous forests. FHM-NC-04-95. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area, State and Private Forestry. 31.

**Attainment**

Manuscripts for laboratory studies initiated in 1991 to evaluate the effects of a single application of *Bacillus thuringiensis* (Bt) on non-target Lepidoptera and in 1995 to evaluate the effect of two applications of Bt, have been prepared and are in review. A manuscript reporting on a field study in Virginia that assessed the effects of a single application of Bt on non-target Lepidoptera, based on foliage and burlap band sampling, has been accepted for publication. Field studies were initiated in 1995 to determine (1) the effects of defoliation caused by high-density gypsy moth populations on native, non-target Lepidoptera. Fifteen plots were established in West Virginia in which macrolepidopteran larvae were collected from burlap bands placed on oak and maple trees. In the treatment plots, gypsy moth populations were substantially reduced. The high density gypsy moth plots were beginning to show significant defoliation when populations were suppressed by an outbreak of the fungus *Entomophaga maimaiga*; consequently no defoliation occurred. The total number of macrolepidopteran larvae collected from low and high GM density plots did not differ significantly, however, numbers differed significantly from those in the treated plots. Plots were resampled during four weeks in 1996 to determine if populations of macrolepidopteran larvae had recovered. Data from this study are being analyzed and a manuscript is being prepared.

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**Problem 4**

**Introduce/establish exotic pathogens i.e. microsporidia to enhance natural control of GM**  
**FY 96 Research Attainments**

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**Publications****Research Unit**

McManus, Michael; Maddox, Joseph; Solter, Leellen; Jeffords, Michael. 1995. Distribution of microsporidia isolated from gypsy moth populations in Europe. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 94. Abstract.

**Cooperative**

Bauer, Leah S.; Miller, Deborah L.; Onstad, David W.; Maddox, Joseph V.; McManus, Michael L. 1995. Studies on the transmission of an exotic microsporidium that infects the gypsy moth. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 50. Abstract.

Onstad, David W.; McManus, Michael L. 1996. Risks of host range expansion by parasites of insects. *BioScience*. 46 (6): 430-435.

Solter, Leellen; McManus, Michael; Maddox, Joseph; Jeffords, Michael. 1995. Infectivity of non-indigenous gypsy moth microsporidia to native non-target forest Lepidoptera. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 92. Abstract.

**Extramural**

Novotny, Julius; Zubrik, Milan. 1995. Mortality agents affecting gypsy moth populations in Slovakia. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 102. Abstract.

Solter, Leellen F. 1995. Interaction of exotic microsporidia with forest Lepidoptera. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 114. Abstract.

**Attainment**

Cooperative agreements have been finalized with scientists in Bulgaria and the Czech Republic to collect and identify microsporidia that are pathogens of the gypsy moth in Eastern Europe. At least 10 isolates have been recovered and are being characterized with the assistance of scientists at the Illinois Natural History Survey. Isolates are evaluated as to their pathogenicity to gypsy moth larvae and to their ability to infect other lepidopteran hosts. Determination of host specificity (host range) is a prerequisite to releasing any of these organisms for biological control of the gypsy moth in North America. A manuscript has been submitted which summarizes our knowledge to date about the specificity of those isolates that are considered to be the best candidates for release. An article was also published in *Bioscience* which discusses the risk of releasing non-indigenous organisms such as the microsporidia. Field studies were initiated in Bulgaria and Slovakia to determine the prevalence of infection by microsporidia in indigenous gypsy moth populations in both countries and to determine if other isolates are present that might be good candidates for biological control. Exploration for microsporidia of the brown-tail moth was initiated in several European countries, the objective being to identify pathogens that might be considered for release against browntail moth populations in Massachusetts and on the coastal islands of Maine.



Problem M1	Develop and evaluate integrated pest management (IPM) strategies to manage the gypsy moth FY 96 Research Attainments
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Publications

Research Unit      McManus, Michael L.; Leuschner, William A. 1995. An economic rationale for slowing the rate of spread of the gypsy moth in the United States. In: Hain, Fred P.; Salom, Scott M.; Ravlin, William F.; Payne, Thomas L.; Raffa, Kenneth F., eds. Behavior, population dynamics and control of forest insects. Proceedings of the IUFRO joint conference; 1994 February 6-11; Maui, HI. Wooster, OH: The Ohio State University, Ohio Agricultural Research and Development Center: 499-513.

Cooperative      Miller, David R.; Reardon, Richard C.; McManus, Michael L. 1995. An atmospheric primer for aerial spraying of forests. FHM-NC-07-05. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area, State and Private Forestry. 17.

Miller, David R.; Wang, Yansen; Ducharme, Kirk M.; Yang, Xiusheng; Mierzejewski, Karl; McManus, Michael L. 1996. Some atmospheric turbulence and stability effects on aerial spray penetration into hardwood forest canopies. Forest Science. 42 (1): 93-101.

Wang, Yansen; Miller, David R.; Anderson, Dean E.; McManus, Michael L. 1995. A Lagrangian stochastic model for aerial spray transport above an oak forest. Agricultural and Forest Meteorology. 76: 277-291.

Extramural      Falchieri, David; Mierzejewski, Karl; Maczuga, Steven. 1995. Effects of droplet density and concentration on the efficacy of Bacillus thuringiensis and carbaryl against gypsy moth larvae (Lymantria dispar L.). Journal of Environmental Science Health. B30 (4): 535-548.

Gray, David R.; Ravlin, F. William. 1995. Geographic robustness of a three-phase model of gypsy moth egg phenology. In: Fosbroke, Sandra, L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 70. Abstract.

Hoch, Gernot; Zubrik, Milan. 1995. The parasitoid complex of the gypsy moth in high and low level populations in eastern Austria and Slovakia. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 79. Abstract.

Maczuga, Steve; Mierzejewski, Karl. 1995. A computer program to predict gypsy moth larval mortality in sprayed forests. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 88. Abstract.

Maczuga, Steven A.; Mierzejewski, Karl J. 1995. Droplet size and density effects of Bacillus thuringiensis kurstaki on gypsy moth (Lepidoptera: Lymantriidae) larvae. Journal of Economic Entomology. 88 (5): 1376-1379.

## Attainment

Several studies have been completed that emphasize the difficulties that are encountered when microbial pesticides such as Bt (*Bacillus thuringiensis*) are applied aerially to hardwood forests. In particular, meteorological conditions at the time of spray are extremely critical in determining the penetration and deposition of Bt in hardwood canopies. Spray models are very useful in predicting depositions of Bt under variable conditions, however, there is still a need to evaluate these models under operational conditions and conduct sensitivity analyses to improve their performance. Recent analyses of the data from pheromone trap grids in the Slow-the-Spread Demonstration project area suggest that spacing between traps can be increased without losing definition about the density and scope of isolated infestations within the project area. These evaluations are critical to the success of the program.

Northeastern Forest Experiment Station  
Forest Protection Research  
Research Work Unit 4505

Disturbance of Eastern Forest Ecosystems by Stressor/Host/Pathogen Interactions  
Wargo, Philip M., Project Leader

FY 96 Research Attainments  
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Determine principal interactions of stressors, hosts, and pathogens causing disturbance gaps	FPR	376	1.7	5		6
2. Gap dynamics from stressor/host/pathogen interactions relate to forest maturation	FPR	86	.6	1		
3. Evaluate risk of forests to disturbance from stressor/host/pathogen interactions	FPR	448	2.3	2		1
4. Integrate research from problems 1-3 into management tools to predict, prevent disturbances	FPR	125	.8	3		1

<b>Problem 1</b>	<b>Determine principal interactions of stressors, hosts, and pathogens causing disturbance gaps</b>
	<b>FY 96 Research Attainments</b>

## Publications

<b>Research Unit</b>	<p>Shortle, W.C.; Smith, K.T.; Dudzik, K.R.; Parker, S. 1995. Response of maple sapwood to injury and infection. <i>European Journal of Forest Pathology</i>. 25: 241-252.</p> <p>Shortle, W.C.; Smith, K.T.; Minocha, R.; Alexeyev, V.A. 1995. Similar patterns of change in stemwood calcium concentration in red spruce and Siberian fir. <i>Journal of Biogeography</i>. 22: 467-473.</p> <p>Smith, K.T.; Shortle, W.C.; Ostrofsky, W.D. 1995. Aluminum and calcium in fine root tips of red spruce collected from the forest floor. <i>Canadian Journal of Forest Research</i>. 25: 1237-1242.</p> <p>Wargo, P.M. 1996. Consequences of environmental stress on oak: predisposition to pathogens. <i>Annales des Sciences Forestieres</i>. 53: 359-368.</p> <p>Wargo, Philip M. 1995. Disturbance in forest ecosystems caused by pathogens and insects. In: Eskew, Lane G., comp. <i>Forest health through silviculture. Proceedings of the 1995 national silviculture workshop; 1995 May 8-11; Mescalero, NM. Gen. Tech. Rep. RM-GTR-267. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 20-25.</i></p>
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<b>Cooperative</b>	<p>Castello, John D.; Wargo, Philip M.; Jacobi, Volker; Bachand, George D.; Tobi, Donald R.; Rogers, Mary A.M. 1995. Tomato mosaic virus infection of red spruce on Whiteface Mountain, New York: prevalence and potential impact. <i>Canadian Journal of Forest Research</i>. 25: 1340-1345.</p> <p>David, Mark B.; Lawrence, Gregory B.; Shortle, Walter C.; Bailey, Scott W. 1996. Calcium status of the forest floor in red spruce forests of the northeastern U.S.—past, present and future. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. <i>Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 118.</i></p> <p>Gove, J.H.; Houston, D.R. 1996. Monitoring the growth of American beech affected by beech bark disease in Maine using the Kalman filter. <i>Environmental and Ecological Statistics</i>. 3: 167-187.</p> <p>Harney, S.K.; Wentworth, T.S. Wargo, P.M. 1995. <i>Phialocephala fortinii</i>, a potential fine root pathogen, isolated from red spruce. <i>Phytopathology</i> 85(10): 1141. Abstract.</p> <p>Lawrence, Gregory B.; David, Mark B.; Shortle, Walter C. 1995. A new mechanism for calcium loss in forest-floor soil. <i>Nature</i>. 378: 162-165.</p> <p>Lawrence, Gregory B.; David, Mark B.; Shortle, Walter C. 1996. Aluminum mobilization and calcium depletion in the forest floor of red spruce forests in the northeastern United States. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. <i>Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 112-117.</i></p>
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## Attainment

Acidic deposition has caused mobilization of aluminum (Al) in forest floors of NE conifer sites and has reduced the availability of calcium (Ca) for root uptake. Root tips in the lower organic horizon had higher Al:Ca ratios indicating reduced Ca availability in a reduced rooting zone for nutrient uptake. Al:Ca ratios were higher in sites with putatively higher stress as indicated by tree mortality. Root tip mortality was higher and mycorrhizal relationships were lower than expected on sites where tree mortality was higher. Chemical analyses of wood cores from mature red spruce in NE show a distinct pattern of decreasing Ca in the wood with distance from the pith. There is a distinct increase in Ca in the wood formed in the 1960's followed by a decline at an even faster rate than in the previous 5 decades. Increased uptake is putatively related to the increased mobilization of cations in soil solution caused by atmospheric deposition from 1950 thru 1970.

Armillaria root disease was prevalent in sugar maple decline in the Allegheny NF and surrounding state forests. Initial studies indicate that the fungus is more abundant and vigorous on plots treated with lime.

Gaps in red maple stands are due frequently to wood decay in the living tree. Extent of decay was dependent on the type of fungi that colonized the wound and the damage to the bark. The protective properties of discolored wood varied depending on the stage of infection and decay.

**Problem 2**

**Gap dynamics from stressor/host/pathogen interactions relate to forest maturation**  
**FY 96 Research Attainments**

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**Publications**

Research Unit

Smith, Kevin T.; Shortle, Walter C.; Minocha, Rakesh; Alexeyev, Vladislav A. 1996. Dynamics of calcium concentration in stemwood of red spruce and Siberian fir. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 230-238.

**Attainment**

Two grand processes, growth, and decay, govern the development of forests. When gaps are created in nature, trees that die and fall are decayed to become a layer of nutrient rich organic matter to help regenerate the openings. When

trees are harvested as part of forest management, a portion of the material available for decay is removed. We have initiated long-term studies to determine the consequences of partial removal of trees, which will not be incorporated into the forest floor, in order to better understand nutrient cycling taking place during forest maturation.

Research is currently underway to determine the effects of stand age on radial growth and the sensitivity of radial growth to climate for both red spruce and Siberian fir.

Other studies on sugar maple decline will relate vulnerability to mortality to stand structure and age and Armillaria species abundance, and vigor.

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**Problem 3**                      **Evaluate risk of forests to disturbance from stressor/host/pathogen interactions**  
**FY 96 Research Attainments**

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**Publications**

**Research Unit**                      Minocha, Rakesh; Shortle, Walter C.; Coughlin, Daniel J., Jr.; Minocha, Subhash C. 1996. Effects of aluminum on growth, polyamine metabolism, and inorganic ions in suspension cultures of red spruce (*Picea rubens*). *Canadian Journal of Forest Research*. 26: 550-559.

Minocha, Rakesh; Shortle, Walter C.; Lawrence, Gregory B.; David, Mark B.; Minocha, Subhash C. 1996. Putrescine: a marker of stress in red spruce trees. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program*; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 119-130.

**Cooperative**                      Bloomfield, Janine; Vogt, Kristiina; Wargo, Philip M. 1996. Tree root turnover and senescence. In: Waisel, Yoav; Eshel, Amram; Kafkafi, Uzi, comps., eds. *Plant roots. The hidden half*. New York, NY: Marcel Dekker: 363-381.

**Attainment**

Molecular markers have been developed that detect change in forest environment that increases stress in trees. Mobilization of Ca, Mg, and Al in the root zone of forest trees by acid deposition creates a band of Ca and Mg enriched wood in the stem of mature trees. Such a band of Ca and Mg enriched wood was found in the stems of red spruce trees in the NE U.S. and Siberian fir trees in Russia. The band was dated to the period 1951-1970, the same period trees were exposed to marked increases in acid deposition, and after which trees declined as Al displaced Ca, Mg in the roots. Foliar putrescine levels were observed to increase in apparently healthy red spruce exposed to increasing Al putrescine, one of a family of organic cations called polyamines which have been shown to be markers of stress in plants, was found to be a useful marker of stress in red spruce. Chemical analyses of soluble carbohydrates, starch, and total phenols in fine nonwoody and woody roots of red spruce demonstrate that these constituents, especially in the fine nonwoody roots, are indicators of stress and change in carbon allocation. In trees growing on putatively stressed sites or on sites treated with (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> fertilization, phenol production increased while the abundance of starch decreased in fine nonwoody roots in "stressed" sites. Using dendrochemical markers of environmental changes in mature tree and biochemical markers of stress in foliage and roots appear to be useful for assessing potential problems in tree populations.

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Problem 4

Integrate research from problems 1-3 into management tools to predict, prevent disturbances

FY 96 Research Attainments

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Publications

Research Unit

Houston, David R. 1995. Effects of paraformaldehyde on sugar maples tapped for sap. II. Temporal development of discoloration and decay. *Phytopathology* 85(12): 1557. Abstract.

Shortle, Walter C.; Smith, Keven T.; Dudzik, Kenneth R. 1996. Decay diseases of stemwood: detection, diagnosis, and management. In: Raychaudhuri, S.P.; Maramorosch, K., comps., eds. *Forest trees and palms: diseases and control*. New Delhi and Calcutta, Oxford & IBM Publishing: 95-109.

Smith, Kevin T. 1995. Trees at risk from good intentions. *Arborist News*. 4 (5): 27-29.

Cooperative

Barker, M.J.; Skilling, D.D.; Houston, D.R.; Ostry, M.E. 1995. Propagation of American beech with resistance to beech bark disease. *Phytopathology* 85(10): 1192. Abstract.

Attainment

Stem diseases of trees are major determinants of wood quality and are the early stage of the decomposition of wood and bark, which is critical for nutrient cycling in the forest. We have recently reviewed decay diseases of stemwood in relation to detection, diagnosis, and management. Knowledge about the effect of external stressors on the internal response of tree infections following injury are key components in managing a healthier forest.

Urban forests are increasingly recognized as having social and economic value in communities. Unfortunately, many urban and community trees carry the records of poor tree care practices. Poor tree care practices are those that ignore basic biology and the fundamental needs of trees. The theme that community good will is not enough to sustain urban forests, but that trees need to be cared for properly and in accordance with their underlying biology has been presented at arborist meetings and published in the arboriculture literature.

Management trials to stimulate or repress sprouting of resistant and susceptible (to beech scale and beech bark disease) beech trees were completed. Data are being analyzed.

Assessments of *Armillaria* root disease in managed and unmanaged stands defoliated by the gypsy moth were completed. Data are being compiled.

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**Northeastern Forest Experiment Station  
Forest Protection Research  
Research Work Unit 4509**

**Development of Biologically Based Controls for Forest Insect Pests and Diseases  
Through Molecular Technologies  
Slavicek, James M., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Fundamental development of biological agents and biorational approaches for insect control	FPR	582	2.9	13	3	2
2. Develop biological and biorational approaches for control of tree diseases	FPR	572	1.8	5		1
3. Use of biotechnology to generate solutions to problems supporting current research	FPR	127	.3	2		

## Problem 1

**Fundamental development of biological agents and biorational approaches  
for insect control  
FY 96 Research Attainments**

## Publications

## Research Unit

Bischoff, D.S.; Slavicek, J.M. 1996. Identification of a LdMNPV gene with homology to the viral enhancing factor gene of TnGV. In: 15th annual meeting of the American Society for Virology; 1996 July 13-17; London, ON. [Place of publ. unknown]: American Society for Virology: 114. Abstract.

Bischoff, David S.; Slavicek, James M. 1995. Identification of the *Lymantria dispar* nuclear polyhedrosis virus 25K gene. Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. In: Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 55. Abstract.

Bischoff, David S.; Slavicek, James M. 1995. Sequence characterization and temporal expression of an early gene in the *Lymantria dispar* nuclear polyhedrosis virus. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 56. Abstract.

Bischoff, David S.; Slavicek, James M. 1995. Identification and characterization of an early gene in the *Lymantria dispar* multinucleocapsid nuclear polyhedrosis virus. *Journal of General Virology*. 76: 2933-2940.

(The accession number for the nucleotide sequence of the LdMNPV G22 gene is U37131.)

Hiremath, Shivanand T.; Lehtoma, Kirsten; Prasad, Roopa. 1995. Complete nucleotide sequencing of a clone encoding the large subunit of vitellogenin from the gypsy moth. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 78. Abstract.

Slavicek, J.M.; Mercer, M.; Plazolles, N.H.; Kelly, M. 1996. Isolation of a LdMNPV polyhedron formation mutant that produces large numbers of occlusion deficient polyhedra. In: 15th annual meeting of the American Society for Virology; 1996 July 13-17; London, ON. [Place of publ. unknown]: American Society for Virology: 170. Abstract.

Slavicek, James M. 1995. Development of enhanced viral strains for cell culture production. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 113. Abstract.

Slavicek, James M. 1995. Development of improved *Lymantria dispar* nuclear polyhedrosis virus strains for virus production in cell culture systems. In: 1995 international chemical congress of Pacific Basin societies; 1995 December 17-22; Honolulu, HI. [Place of publ. unknown]: [Publisher name unknown]. Abstract.

Slavicek, James M.; Mercer, Melissa J., inventors. The United States of America as represented by the Secretary of Agriculture, assignee. Method of protecting plants from insects by applying gypsy moth virus with enhanced polyhedra production stability 1995. U.S. Patent 5,462,732. 1995 October 31. Int. C16 A01N 63/00; U.S. CL. 424/93.2.

Slavicek, James M.; Mercer, Melissa J.; Kelly, Mary Ellen; Hayes-Plazolles, Nancy. 1996. Isolation of a baculovirus variant that exhibits enhanced polyhedra production stability during serial passage in cell culture. *Journal of Invertebrate Pathology*. 67: 153-160.

Valaitis, Algimantas P. 1995. *Bacillus thuringiensis* CryIA insecticidal toxins effect rapid release of gypsy moth midgut epithelium aminopeptidase. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 118. Abstract.

Valaitis, Algimantas P.; Lee, Mi Kyong; Rajamohan, Francis; Dean, Donald H. 1995. Identification of the *Bacillus thuringiensis* CryIAc toxin binding protein in the gypsy moth midgut. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 119. Abstract.

Valaitis, Algimantas P.; Lee, Mi Kyong; Rajamohan, Francis; Dean, Donald H. 1995. Brush border membrane Aminopeptidase-N in the midgut of the gypsy moth serves as the receptor for the CryIA(c) delta-endotoxin of *Bacillus thuringiensis*. *Insect Biochemistry and Molecular Biology*. 25 (10): 1143-1151.

(Portions of this work were funded by grants from National Institutes of Health, AI 29092 and USDA Forest Service to D.H.D.)

#### Cooperative

D'Amico, Vincent; Elkinton, Joseph S.; Wood, H. Alan; Podgwaite, John D.; McManus, Michael L.; Slavicek, James; Burand, John P. 1995. A field test of genetically engineered gypsy moth NPV. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 61. Abstract.

Hendrix, D.L.; Perkins, H.H., Jr.; Valaitis, A. 1995. Chemical characterization of cotton insect honeydew and elimination of stickiness of honeydew-contaminated lint. In: Constable, G.A., Forrester, N.W., eds. Challenging the future: proceedings of the world cotton research conference; 1994 February 14-17; Brisbane, Australia. East Melbourne, Australia: CSIRO Australia: 437-441.

#### Extramural

Du, X.; Thiem, S.M. 1996. Characterization of host range factor 1 (hrf-1) expression in *Lymantria dispar* M nuclear polyhedrosis virus (MNPV) and recombinant *autographa californica* MNPV-infected LD652Y cells. In: 15th annual meeting of the American Society for Virology; 1996 July 13-17; London, ON. [Place of publ. unknown]: American Society for Virology: 153. Abstract.

Thiem, Suzanne M.; Du, Xianlin; Berner, Michelle; Quentin, Martha; Chilcote, Charley. 1995. Identification of a *Lymantria dispar* nuclear polyhedrosis virus host range gene. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 116. Abstract.

Thiem, Suzanne M.; Du, Xianlin; Quentin, Martha E.; Berner, Michelle M. 1996. Identification of a baculovirus gene that promotes *autographa californica* nuclear polyhedrosis virus replication in a nonpermissive insect cell line. *Journal of Virology*. 70 (4): 2221-2229.

(This work was supported in part by Cooperative Research Agreement 23-816 with the Northeastern Forest Experiment Station, Forest Service, U.S.D.A., and by Public Health Service Grant GM48608 from the National Institute of General Medical Sciences to S.M.T.)

**Attainment**

Gypsy moth virus research: A strain of the *Lymantria dispar* nucleopolyhedrovirus (LdMNPV) was developed that forms few polyhedra mutants at a lower frequency compared to wild type virus during viral production in cell culture. The use of this viral strain to control the gypsy moth was patented. An immediate early gene in LdMNPV was identified and characterized. This gene has not been found in any other NPV studied to date, and may be necessary for viral replication and cirulence. A novel LdMNPV polyhedron formation mutant was identified and characterized at the phenotypic level. *Bacillus thuringiensis* research: Bt CryIA(c) toxin binds to aminopeptidase N (APN), a glycoprotein located on the *L. dispar* midgut brush border membrane. Two APNs, APN-1 and APN-2, were purified and their ability to bind Bt toxins was examined. Only APN-1 can bind toxin. The kinetic characteristics of APN-1 were examined by ligand binding, competition studies, and surface plasmon resonance using an optical biosensor. A specific antibody to APN-1 was produced, and N-terminal and internal sequences were obtained to enable cloning of the receptor gene. Insect hormone research: In the gypsy moth, the juvenile hormone suppresses expression of vitellogenin (Vg), precursor of a developmentally-regulated and female-specific egg yolk protein. In order to understand the mechanism of action of the hormone, the gene encoding the Vg was isolated and characterized. Determination of the complete nucleotide sequence of the clone indicated the presence of several introns. The sequences encoding the N-terminus of the large subunit of Vg and the upstream regulatory sequences were identified. The promoter elements of the gene will be used in identifying and isolating the juvenile hormone receptor.

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<b>Problem 2</b>	<b>Develop biological and biorational approaches for control of tree diseases FY 96 Research Attainments</b>
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**Publications****Research Unit**

Eshita, Steven M.; Koch, Jennifer L.; Kamalay, Joseph C. 1996. Pathogenesis-related proteins that show similarity to PR-10 proteins were induced in American elm xylem by infection with the Dutch elm disease fungus. In: 8th international congress on molecular plant-microbe interactions; 1996 July 14-19; Knoxville, TN. [Place of publ. unknown]: [Publisher name unknown]. Abstract.

Eshita, Steven M.; Roberto, Nick H.; Beale, John M.; Mamiya, Blain M.; Workman, Ryan F. 1995. Bacillomycin Lc, a new antibiotic of the iturin group: isolations, structures, and antifungal activities of the congeners. *Journal of Antibiotics*. 48 (11): 1240-1247.

Kamalay, J.C.; Carey, D.W. 1995. Application of RAPD-PCR markers for identification and genetic analysis of American elm (*Ulmus americana* L.) selections. In: *Arboricultural Abstracts: International Society for Arboriculture*; Savoy, IL: Section 5: No. 14. 1996 April 1. Abstract.

Kamalay, Joseph C.; Carey, David W. 1996. Using DNA markers to identify American elm. *American Nurseryman*. (April 15): 56-57. Abstract.

Kamalay, Joseph C.; Carey, David W. 1995. Application of RAPD-PCR markers for identification and genetic analysis of American elm (*Ulmus americana* L.) selections. *Journal of Environmental Horticulture*. 13 (4): 155-159.

**Cooperative**

Schreiber, Lawrence R.; Domir, Subhash C.; Gingas, V.M. 1996. Identification and control of bacterial contamination in callus cultures of *Ulmus americana*. *Journal of Environmental Horticulture*. 14 (2): 50-52.

**Attainment**

Dutch Elm disease research: Xylem proteins have been identified in *Ulmus americana* that are induced in a susceptible response to inoculation with *Ophiostoma ulmi*. N-terminal sequence was determined for two of the low molecular weight proteins that are induced. One shares homology with the PR-10 family of pathogenesis-related proteins, with strong homology to the tree pollen allergens of the order Fagales. The other peptide sequence was novel, possibly a previously unclassified PR protein. Although PR-10 proteins are reported to be very stable, the RNA that encodes them is transiently expressed. To obtain tissues enhanced for the putative elm PR-10 RNA, a time course inoculation experiment was performed. The original susceptible tree was used as well as a selection with moderate resistance, Delaware 3. Tissues from the inoculated trees were harvested at three different time points and are currently being prepared for use in polymerase chain reactions with primers derived from the N-terminal sequences in order to obtain cDNA clones of the putative elm PR proteins. DNA profile methods for use in distinguishing elm tree genotypes were published and several outlets announced the findings to the Horticulture/Nursery industry. We used the profiles to identify trees for the National Arboretum and for two national level tree nurseries. Propagation of trees for the 1999 field bioassays included micropropagation. Cells from 4 additional American elm genotypes were used to initiate new suspension cell cultures for use to verify previous results and to include high DED-tolerance level trees. Elicited gene expression from cultured cells was analyzed for differences in proteins and mRNAs. Further background and reagents were obtained for genetic engineering of elms.

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<b>Problem 3</b>	<b>Use of biotechnology to generate solutions to problems supporting current research</b>
	<b>FY 96 Research Attainments</b>

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**Publications****Research Unit**

Garner, K.J.; Slavicek, J.M. 1996. Identification and characterization of a RAPD-PCR marker for distinguishing Asian and North American gypsy moths. *Insect Molecular Biology*. 5 (2): 81-91.

Garner, Karen; Schreiber, David; Slavicek, James. 1995. Status of nuclear DNA markers. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. In: *Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. 213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 69. Abstract.*

**Attainment**

**Oak wilt disease research:** The PCR-based method previously reported for use in the species specific detection of *Ceratocystis fagacearum* (the oak wilt fungus) in insect vector studies has been successfully used to detect DNA from a single spore. *C.fagacearum* DNA has also been successfully distinguished from several other closely related species of non-pathogenic fungi that are common contaminants found on potential insect vectors. Additional work has been done to identify nuclear markers for distinguishing between strains of *C.fagacearum* in epidemiological studies. 144 arbitrary 10-mer primers were used to randomly amplify DNAs from eight fungal isolates (5 from different counties in Texas and one in Ohio) to identify polymorphisms. The results demonstrate that *C.fagacearum* has a low level of nuclear DNA sequence variability. However, one primer identified polymorphisms that divided the isolates into two subgroups, and another primer distinguished individual isolates. Two of the polymorphic bands have been cloned and are currently being sequenced so that sequence specific primer pairs can be developed to amplify a single polymorphic locus.

**Asian gypsy moth research:** The nuclear DNA marker, FS-1, for use in distinguishing the Asian and North American gypsy moth strains was developed. This marker is being used by the Animal and Plant Health Inspection Service, Agriculture Canada, and the Institute for Plant Protection in Forests in Germany.

**Beech bark disease research:** American beech DNA profiles allowed the contrast of diversity between 2 forest clines and the determination of tree relatedness. The predicted relationships of the tree samples taken are being contrasted with isozyme results.

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Northeastern Forest Experiment Station  
Forest Protection Research  
Research Work Unit 4557

Silvicultural Options for the Gypsy Moth  
Gottschalk, Kurt W., Project Leader

FY 96 Research Attainments  
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Effects of damage by the gypsy moth and its associated organisms in various types of stands	FPR	392	1.2	3		
2. Silvicultural practices in reducing damage to forest stands by the gypsy moth	FPR	392	.8	1	1	
3. Develop and evaluate decision-making systems to manage the gypsy moth	FPR	804	2.0	2		9
5. Global Change Program	FPR	100	.7	2		
6. Miscellaneous	FPR	0	.0	2		3

Problem 1

Effects of damage by the gypsy moth and its associated organisms in various types of stands  
FY 96 Research Attainments

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Publications

Research Unit

Liebhold, Andrew M.; Gottschalk, Kurt W.; Muzika, Rose-Marie; Montgomery, Michael E.; Young, Regis; O'Day, Kathleen. 1996. Suitability of North American tree species to the gypsy moth: summary of field and laboratory tests. Gen. Tech. Rep. NE-211. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 34.

Muzika, Rose-Marie; Gottschalk, Kurt W. 1995. Gypsy moth role in forest ecosystems: the good, the bad, and the indifferent. In: Eskew, Lane G., comp. Forest health through agriculture. Proceedings of the 1995 national silviculture workshop; 1995 May 8-11; Mescalero, NM. Gen. Tech. Rep. RM-GTR-267. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 99-104.

Muzika, Rose-Marie; Hunsucker, Robert; DeMeo, Tom. 1996. Botanical reconnaissance of Big Run Bog candidate research natural area. Gen. Tech. Rep. NE-223. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 15.

Attainment

Recent publications in the area of impact of gypsy moth reflect the importance of integrating information. Synthesis of the literature has helped to define and describe species level impacts of defoliation. For example, in a recent publication we identified the suitability of every woody species in North America as hosts of gypsy moth; this information will clarify anticipated impacts. Continued exploration of ecological communities throughout the Appalachians helps in understanding the significance of introduced pests in general on various ecological systems. Forest health figures significantly in recent publications, and we have also begun to synthesize our research from the past few years in terms of overall effect of gypsy moth. Often neglected is the effect of gypsy moth and exotic pests in general on the functional responses of ecological systems. Within a long-term context for forests of the Northeast, gypsy moth appears to more strongly affect the rate of processes such as succession than to account for overall compositional change.

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**Problem 2**                      **Silvicultural practices in reducing damage to forest stands by the gypsy moth**  
**FY 96 Research Attainments**

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**Publications**

**Research Unit**                      Gottschalk, Kurt W. 1995. Using silviculture to improve health in northeastern conifer and eastern hardwood forests. In: Eskew, Lane G., comp. Forest health through silviculture. Proceedings of the 1995 national silviculture workshop; 1995 May 8-11; Mescalero, NM. Gen. Tech. Rep. RM-GTR 267. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 219-226.

**Extramural**                      Twery, Mark J.; Gottschalk, Kurt W. 1996. Forest health: another fuzzy concept. Journal of Forestry (Side Bar). 94 (8): 20.

**Attainment**

Long-term studies of the use of silviculture to minimize gypsy moth effects are continuing. A review of the use of silviculture to improve health of northeastern conifer and eastern hardwood forests was conducted. The role of silviculture in the context of insects and diseases involves the reduction of forest susceptibility to insects and diseases. Examples of forest-pest systems where silviculture can be effective are: Spruce-fir forests and spruce budworm; white pine and mixed white-pine oak forests for white pine blister rust and white pine weevil; jack pine forests for jack pine budworm; northern hardwood forests for beech bark disease; oak-hickory forests for gypsy moth and oak decline; and several other hardwood types and defoliators. The long-term role of silvicultural treatments in maximizing forest health needs to be evaluated for its influence on other ecosystem components.

<b>Problem 3</b>	<b>Develop and evaluate decision-making systems to manage the gypsy moth FY 96 Research Attainments</b>
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**Publications**

<b>Research Unit</b>	<p>Colbert, J.J.; Xu, Rumei; Jiang, Nan-qing. 1995. A simplified gypsy moth system: model definition and description. <i>Computers and Electronics in Agriculture</i>. 13 (2): 115-131.</p> <p>Liebhold, Andrew; Zhou, Guofa; Gribko, Linda; Hohn, Michael. 1994. Models that predict the spatial dynamics of gypsy moth <i>Lymantria Dispar</i> (L.) populations. In: Hain, Fred P.; Salom, Scott M.; Ravlin, William F.; Payne, Thomas L.; Raffa, Kenneth F., eds. <i>Behavior, population dynamics and control of forest insects. Proceedings of the IUFRO joint conference; 1994 February 6-11; Maui, HI.</i> Wooster, OH: The Ohio State University, Ohio Agricultural Research and Development Center: 491-498.</p>
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<b>Cooperative</b>	<p>Ghent, John H.; Thomas, Susan J.; Twardus, Daniel B.; Gottschalk, Kurt W.; Teske, Milton E. 1996. A demonstration of gypses: the gypsy moth decision support system. Tech. Pap. 961036. St. Joseph, MI: American Society of Agricultural Engineers. 6.</p> <p>Jiang, Nan-qing; Xu, Rumei; Colbert, J.J. 1995. A simplified gypsy moth model system: global behavior and parameter analysis. <i>Computers and Electronics in Agriculture</i>. 13 (2): 133-153.</p> <p>Sharov, Alexei A.; Colbert, J.J. 1996. A model for testing hypotheses of gypsy moth, <i>Lymantria dispar</i> L., population dynamics. <i>Ecological Modelling</i>. 84: 31-51.</p> <p>Sharov, Alexei A.; Liebhold, Andrew M.; Ravlin, F. William. 1995. Prediction of gypsy moth (Lepidoptera: Lymantriidae) mating success from pheromone trap counts. <i>Environmental Entomology</i>. 24 (5): 1239-1244.</p> <p>Sharov, Alexei A.; Roberts, E. Anderson; Liebhold, Andrew M.; Ravlin, F. William. 1995. Gypsy moth (Lepidoptera: Lymantriidae) spread in the central Appalachians: three methods for species boundary estimation. <i>Environmental Entomology</i>. 24 (6): 1529-1538.</p> <p>Twardus, Daniel B.; Ghent, John H.; Thomas, Susan J.; Gottschalk, Kurt W.; Teske, Milton E. 1996. An overview of gypses: the gypsy moth decision support system. Tech. Pap. 961035. St. Joseph, MI: American Society of Agricultural Engineers. 8.</p> <p>Wilder, J.W.; Christie, I.; Colbert, J.J. 1995. Modelling of two-dimensional spatial effects on the spread of forest pests and their management. <i>Ecological Modelling</i>. 82: 287-298.</p> <p>Wilder, J.W.; Vasquez, D.A.; Christie, I.; Colbert, J.J. 1995. Wave trains in a model of gypsy moth population dynamics. <i>CHAOS</i>. 5 (4): 700-706.</p> <p>Zhou, Guofa; Liebhold, Andrew M. 1995. Forecasting gypsy moth defoliation with a geographical information system. <i>Entomologai Senica</i>. 2 (1):</p>
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**Attainment**

Research progress has occurred in several modeling areas. A simplified gypsy moth model system using three-stage discrete equations was developed and its behavior described. These models are useful for theoretical research on modeling. A previously-developed model of three differential equations was modified to study the spread of gypsy moth populations. The behavior of the earlier differential equation model was described in terms of wave trains and chaos. Landscape models for forecasting gypsy moth defoliation were developed and tested. Gypsy moth spread models were refined by the development of techniques for estimating the boundary of gypsy moth populations as they spread into the Central Appalachians. These techniques will be useful for evaluating the effectiveness of the Slow-the-Spread program. The gypsy moth decision support system, GypsES, has been enhanced by the addition of the Stand Damage Model, further enhancement to the FSCBG spray deposition model and the addition of digital GPS files for uploading spray blocks and downloading spray lines from aircraft guidance systems. GypsES is now being used by 25+ county, state and federal agency sites.

**Problem 5****Global Change Program  
FY 96 Research Attainments**

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**Publications****Research Unit**

Williams, David W.; Liebhold, Andrew M. 1995. Herbivorous insects and global change: potential changes in the spatial distribution of forest defoliator outbreaks. *Journal of Biogeography*. 22: 665-671.

Williams, David W.; Liebhold, Andrew M. 1995. Influence of weather on the synchrony of gypsy moth (Lepidoptera: Lymantriidae) outbreaks in New England. *Environmental Entomology*. 24 (5): 987-995.

**Attainment**

Several approaches were applied to examine the relationships between forest insect spatial dynamics and weather at the landscape scale. Synchrony in the onset of outbreaks of geographically disjunct populations has been observed in several forest insect species. Historical records of gypsy moth outbreaks in the northeast were found to support the explanation of the synchrony based upon the "Moran-effect:" populations are primarily driven by density-dependent processes but the density-independent effects of weather on dynamics occur synchronously over large geographical areas (due to large scale weather anomalies) and this serves to bring populations into synch.

In another analysis, the spatial distribution of outbreaks of the gypsy moth and western spruce budworm were modeled as functions of forest vegetation and climate. These models were used to examine the potential effects of global climate change on outbreak patterns. Results indicated that effects on insect outbreak distributions varied considerably among the outputs of various global circulation models tested.

Problem 6

Miscellaneous  
FY 96 Research Attainments

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Publications

Research Unit                      Colbert, J.J. 1995. Introduction: models as links between empiricism and theory in insect ecology. *Computers and Electronics in Agriculture*. 13 (2): 87-90.

Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. 1995. *Proceedings, U.S. Department of Agriculture Interagency gypsy moth research forum*. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 133.

Cooperative                      DeBenedictis, John A.; Liebhold, Andrew M.; Powell, Jerry A. 1995. Studies of pheromone attraction and inheritance using virgin females of *Choristoneura* species, in the Central Sierra Nevada, California. In: Powell, Jerry A., ed. *Biosystematic studies of conifer-feeding Choristoneura (Lepidoptera: Tortricidae) in the western United States*. Vol. 115. Berkeley, CA: University of California Press: 153-165.

Dix, Mary Ellen; Jennings, Daniel T. 1995. Predation by *Misumenop Asperatus* (Araneae, Thomisidae) on the metallic pitch nodule moth *Retinia Metallica* (Lepidoptera, Tortricidae). *Journal of Arachnology*. 23: 207-208.

Williams, L.E.; Williams, D.W.; Phene, C.J. 1993. Modelling grapevine water use. In: Stockley, Creina S.; Johnstone, Russell S.; Leske, Peter A.; Lee, Terry H., eds. *Proceedings of the 8th Australian Wine Industry Technical Conference; 1992 October 25-29; Melbourne, Australia*. Urrbrae, South Australia: Australian Wine Research Institute:

Attainment                      The USDA Interagency gypsy moth research forum proceedings presents the results of research on gypsy moth biology, molecular biology, ecology, impacts and management. Spruce budworm pheromone attraction and inheritance showed a hybrid zone where identities of adults are uncertain. A crab spider is an important predator of the ponderosa pine pest, metallic pitch module moth. A symposium held at the 19th International Congress of Entomology entitled "models as links between empiricism and theory in insect ecology" was summarized and the papers published as a special issue of *Computers and electronics in agriculture*.

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Northeastern Forest Experiment Station  
Forest Protection Research  
Research Work Unit 4558

Impact of Atmospheric Deposition and Global Change on Forest Health and Productivity  
Long, Robert P., Project Leader

FY 96 Research Attainments  
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Effect of atmos. dep. stress/change in global climate on tree growth and other variables	FPR	135	3.0	5	1	2
2. Deter. effects of atmos. dep. on mature trees and how effects differ from those found in seedlings	FPR	80	1.0	1		

<b>Problem 1</b>	<b>Effect of atmos. dep. stress/change in global climate on tree growth and other variables</b>
	<b>FY 96 Research Attainments</b>

**Publications**

**Research Unit**

Long, R.P.; Horsley, S.B.; Lilja, P.R. 1996. Nutrient status and sugar maple health: liming effects on growth, vigor, seed crops, regeneration, and foliage chemistry in northcentral Pennsylvania. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 74. Abstract.

McQuattie, Carolyn J. 1996. Cytological changes in needles of ectomycorrhizal and nonmycorrhizal pitch pine seedlings exposed to aluminum at two nutrient levels. Ohio Journal of Science. 96(2): A-27. Abstract.

McQuattie, Carolyn J.; Schier, George A. 1995. Effects of elevated carbon dioxide on the cytological responses of pitch pine mycorrhizae to aluminum at two nutrient levels. In: Topa, Mary A.; Rygiewicz, Paul T.; Cumming, Jonathan R., comps., eds. Dynamics of physiological processes in woody roots; 1995 October 8-11; Ithaca, NY. Ithaca, NY: Boyce Thompson Institute for Plant Research: 90. Poster Abstract.

(Also sponsored by U.S. Environmental Protection Agency and IUFRO Root Physiology and Symbiosis Working Party, S2.01.13.)

Schier, George A.; McQuattie, Carolyn J. 1995. Uptake and transport of nutrients in mycorrhizal and nonmycorrhizal pitch pine seedlings treated with aluminum. In: Topa, Mary A.; Rygiewicz, Paul T.; Cumming, Jonathan R., comps., eds. Dynamics of physiological processes in woody roots; 1995 October 8-11; Ithaca, NY. Ithaca, NY: Boyce Thompson Institute for Plant Research: 98. Poster Abstract.

(Also sponsored by U.S. Environmental Protection Agency and IUFRO Root Physiology and Symbiosis Working Party, S2.01.13.)

Schier, George A.; McQuattie, Carolyn J. 1996. Effects of carbon dioxide enrichment on response of pitch pine grown at different nutrient levels to aluminum. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 31. Abstract.

**Cooperative**

Heagle, Allen S.; Miller, Joseph E.; Chevone, Boris I.; Dreschel, Thomas W.; Manning, William J.; McCool, Patrick M. 1995. Response of a white clover indicator system to tropospheric ozone at eight locations in the United States. Water, Air and Soil Pollution. 85: 1373-1378.

(Morrison, C. Lynn; Neely, Grady E., Rebbeck, Joanne are co-authors.)

Stout, S.L.; Nowak, C.A.; Horsley, S.B.; Long, R.P.; White, R.; McWilliams, W.; Omer, J.; Lilja, P. 1996. Forest health on Pennsylvania's Allegheny Plateau. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 435-436. Poster Abstract.

**Extramural**

McQuattie, Carolyn; Martin, Kendall; Rygiewica, Paul. 1996. Effects of elevated carbon dioxide and temperature on cytological changes in Douglas fir ectomycorrhizae. In: Szaro, Timothy M.; Bruns, Thomas D., comps., eds. Program and abstracts: First international conference on mycorrhizae; 1996 August 4-9; Berkeley, CA. [Place of publication unknown]: [Publisher name unknown]: 85. Poster Abstract.

## Attainment

Research investigating tree seedling responses to environmental stresses focused on interactions between various abiotic factors and biotic organisms. Pitch pine (*Pinus rigida*) seedlings inoculated with the ectomycorrhizal fungus *Pisolithus tinctorius* were grown in three different nutrient regimes (low-1X, medium-2X, and high-4X) for 13-15 weeks in sand irrigated with a nutrient solution (pH 3.5) containing 0, 6.25, 12.5, or 25 mg/L aluminum (A1) in growth chambers fumigated with 350 (ambient) or 700 (elevated) uL/L carbon dioxide (C02). At all nutrient levels without A1, seedlings grown in elevated C02 had greater numbers of mycorrhizal roots than seedlings grown at ambient C02. Symptoms of A1 toxicity differed depending on nutrient level. At the 1X nutrient level, A1 injury was evident for the 12.5 and 25 mg/L A1 concentrations at both C02 levels; at the 4X nutrient level no needle chlorosis from A1 was evident. Transmission electron microscopy (TEM) cytological studies revealed that A1 disrupted mantle hyphae, but this disruption was greater at ambient C02 than at elevated C02. A1-induced vacuolation of root meristem cells was also greater at ambient C02 than at elevated levels regardless of nutrient regime.

A liming study associated with other sugar maple decline research on the Allegheny Plateau in Pennsylvania has established that exchangeable calcium (Ca) and magnesium (Mg) are limiting to maple health on many unglaciated sites. In addition to increasing growth and vigor of overstory sugar maple, liming also was shown to increase flower and seed crop size, but not frequency.

<b>Problem 2</b>	<b>Deter. effects of atmos. dep. on mature trees and how effects differ from those found in seedlings</b>
	<b>FY 96 Research Attainments</b>

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**Publications**

<b>Research Unit</b>	Rebbeck, Joanne. 1996. The chronic response of yellow-poplar and eastern white pine to ozone and elevated carbon dioxide: three-year summary. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 23-30.
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**Attainment**

The chronic responses of yellow-poplar (*Liriodendron tulipifera*) and eastern white pine (*Pinus strobus*) to ozone (O<sub>3</sub>) and elevated carbon dioxide (CO<sub>2</sub>) are being studied in a long-term open-top chamber fumigation study. Seedlings were fumigated from mid-May to mid-October from 1992 through 1995 under ambient light, nutrient, and moisture conditions in a plantation site. Treatments, replicated three times, include: charcoal-filtered air (CF), 1X ambient O<sub>3</sub> (1X), 2X ambient O<sub>3</sub> (2X), 2X ambient O<sub>3</sub> plus 700 ppm CO<sub>2</sub> (2X+CO<sub>2</sub>), and open-air (QA) chamberless plot. Biomass and growth stimulations were observed on yellow-poplar as early as 1993, with mean increases of 14% in stem diameter and 16% in total plant height of yellow-poplar in 2X+CO<sub>2</sub> compared with all other treatments. By 1994, results indicated total height and basal stem diameter of the 2X+CO<sub>2</sub>-grown yellow-poplar were 21% greater than for all other treatments. No significant treatment effects have been detected on eastern white pine.

**Northeastern Forest Experiment Station  
Forest Products and Harvesting Research  
Research Work Unit 4701**

**Improved Processing Technology for Hardwoods  
Wiedenbeck, Janice K., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Need to develop techniques to evaluate production /economic implications using new technologies	FPHR	76	6.7	12	3	4
2. Standards and test criteria needed for evaluating CNC machinery and tooling	FPHR	0	.0		1	
3. Techniques needed to make existing information available to decision makers	FPHR	7	.0		1	

**Problem 1**

**Need to develop techniques to evaluate production /economic implications using new technologies**  
**FY 96 Research Attainments**

**Publications****Research Unit**

Adams, Edward L. 1996. PC-SOLVE III user's manual: a procedural guide for computer-based sawmill analysis. Gen. Tech. Rep. NE-215. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 36.

Anderson, R. Bruce; Patterson, David W. 1996. Getting it right with automated quality control. Furniture Design & Manufacturing. (2): 132-135.

(Work conducted through a formal Cooperative Agreement with West Virginia University.)

Gatchell, Charles J. 1996. Designing a fixed-blade gang rip saw arbor with a pencil. Forest Products Journal. 46 (6): 37-40.

Gatchell, Charles J.; Wiedenbeck, Jan. 1995. Cross cutting step offers numerous advantages, research shows. Modern Woodworking. October: 7, 12.

Gatchell, Charles J.; Wiedenbeck, Janice K.; Walker, Elizabeth S. 1996. The effects of cross-cutting before gang-ripping on dimension part yields from No. 1 and No. 2A Common red oak lumber. Forest Products Journal. 46 (2): 61-66.

Thomas, Edward; Wiedenbeck, Jan; Hoff, Kris. 1996. Make informed decisions in the rough mill using new and improved computer simulation programs. In: Szymani, Ryszard, ed. Proceedings of CIFAC 1996 international symposium; 1996 May 7-8; High Point, NC. Berkeley, CA: Wood Machining Institute: 47-56.

Thomas, R. Edward. 1996. ROMI-RIP: an analysis tool for rip-first roughmill operations. Forest Products Journal. 46 (2): 57-60.

Wiedenbeck, Jan; Scheerer, Cathy. 1996. A report on rough mill yield practices and performance—how well are you doing? In: Hardwood Symposium Proceedings; 1996 May 8-11; Cashiers, NC. Memphis, TN: Hardwood Research Council:

Wiedenbeck, Jan; Scheerer, Cathy. 1996. Wood component makers commit to yield improvement. Wood & Wood Products. 101 (8): 206,208,211,372.

Wiedenbeck, Jan; Thomas, R. Ed. 1995. Increasing opportunities for yield improvement. Modern Woodworking. November: 21.

Wiedenbeck, Jan; Thomas, R. Ed. 1995. Rough mill study identifies yield improvement opportunities. Millwork Manufacturing. 12 (3): 22-23.

Wiedenbeck, Janice K.; Buehlmann, Urs. 1996. Character in furniture: using more of the wood resource. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 64. Abstract.

**Cooperative**

Kline, D. Earl; Widoyoko, Agus; Wiedenbeck, Janice K.; Araman, Philip A. 1996. Yield-based performance evaluation of a rough-mill scanning-optimization system. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 27. Abstract.

(Assisted in research planning data collection and served on graduate committee for graduate student research that produced this information. SE-4702 also was a contributor but to a lesser extent.)

Lawson, Penny S.; Thomas, R. Edward; Walker, Elizabeth S. 1996. OPTIGRAMI V2 user's guide. Gen. Tech. Rep. NE-222. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 46.

(NE-4803 will claim senior authorship.)

Patterson, David W.; Anderson, R. Bruce. 1996. Use of statistical process control in the furniture and cabinet industries. Forest Products Journal. 46 (1): 36-38.

(Work conducted through a formal Cooperative Agreement with West Virginia University.)

Shupe, Todd F.; Choong, Elvin T.; Stokke, Douglas D.; Gibson, Mark D. 1996. Variation in cell dimensions and fibril angle for two fertilized even-aged loblolly pine plantations. *Wood and Fiber Science*. 28 (2): 268-275.

(Stokke assisted with microscopy and reviewed the manuscript. A portion of the work was done after he was assigned to NE-4701.)

#### Extramural

Kline, Earl D. 1995. Solving real manufacturing problems with computer simulation. *Modern Woodworking*. November: 16, 38.

(Fifty percent of material in this publication was produced as part of a Cooperative Agreement with NE-4701.)

Patterson, David W.; XIE, Sialoin (Sylvia). 1996. Structural beams from small-diameter Appalachian hardwood logs turned inside out. In: *Forest Products Society annual meeting: abstracts: 1996 June 23-26; Minneapolis, MN*. Madison, WI: Forest Products Society: 53. Abstract.

(Work funded in part through a Cooperative Agreement with NE-4701.)

Widoyoko, Agus. 1996. Evaluation of color-based machine vision for lumber processing in furniture rough mills. Blacksburg, VA: Virginia Polytechnic Institute & State University. 88. M.S. thesis.

(Assisted in research planning and data collection and served on graduate committee for graduate student research that resulted in this thesis. SE-4702 also was a contributor but to a lesser extent.)

#### Attainment

During FY96, we achieved notable progress and results on three research studies: (1) development and testing of lumber preprocessing strategies in secondary processing, (2) examination of the relationship between technologies/manufacturing strategies and yield performance for producers of wood component parts, and (3) evaluation of quality control practices and needs in secondary wood processing operations. The results of the first of these studies indicated secondary wood processors can improve rough mill processing efficiency if they use a crosscut saw prior to gang ripping to remove crook and worthless material and take advantage of quality differences between board ends. The second study provides yield performance benchmark information to processors and relates yield performance to raw material and product specifications as well as processing equipment and methods. Both of these studies utilized the ROMI-RIP simulator produced by NE-4701 in 1995. Development of the ROMI-CROSS simulator, a crosscut-first cutup simulator that is fully compatible with ROMI-RIP, has progressed quickly; ROMI-CROSS is now being beta tested. In addition, an important decision support tool produced at the Princeton Laboratory in the 1980's and highly demanded by both the public and researchers was upgraded this past year. PC-SOLVE III is a sawmill analysis system used by lumber manufacturers to estimate the efficiency and costs of operations for different log inputs.

**Problem 2**                      **Standards and test criteria needed for evaluating CNC machinery and tooling**  
**FY 96 Research Attainments**

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**Publications**

**Extramural**                      Stewart, John; Lemaster, Richard. 1995. NC State program offers new advances in tooling. Modern Woodworking. December: 1, 8-9.

(Fifty percent of material in publication relates to work done under Cooperative Agreement with NE-4701.)

**Attainment**

Work under Problem 2 was completed in FY95. This problem will be officially terminated with the rewrite of the Research Work Unit Description that will be completed during FY97.

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**Problem 3**

**Techniques needed to make existing information available to decision makers**  
**FY 96 Research Attainments**

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**Publications****Extramural**

Araman, Philip A.; West, Cynthia D. 1996. Announcing...the Hardwood Utilization Consortium. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 47. Abstract.

(Submitted title, abstract for poster, and provided materials.)

**Attainment**

During FY96 our wood processing information system's research and development focus was on collecting information on wood processing computer programs available to researchers and industry for system analysis and optimization. This information is being assembled into a publication. For the second year in a row, more than 40 percent of the information requests (700+) that we responded to related to rough mill processing yield. We are making a determined effort to bring about this shift so that this program is more aligned with our research and technology transfer needs under Problem 1.

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**Northeastern Forest Experiment Station  
Forest Products and Harvesting Research  
Research Work Unit 4751**

**Systems to Integrate Harvesting With Other Resource Management Objectives  
LeDoux, Chris, Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Inadequate forest management planning tools for steep terrain	FPHR	100	.5	1		
2. Inadequate methods to plan/carry out multiproduct harvest/util. of E. hardwood on steep terrain	FPHR	100	.5			1

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**Problem 1**  
**Inadequate forest management planning tools for steep terrain**  
**FY 96 Research Attainments**

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**Publications****Research Unit**

LeDoux, Chris B.; Gopalakrishnan, B.; Mudiyanur, Sheshadri. 1996. Maximizing financial yields while meeting landowner objectives and ecosystem goals. In: Blinn, Charles R. and Thompson, Michael A., eds. Planning and implementing forest operations to achieve sustainable forests: proceedings of joint meeting of Council on Forest Engineering and IUFRO; 1996 July 29-August 1; Marquette, MI. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station:

**Attainment**

An integrated expert system called FOREX was used to evaluate landowner's personal management objectives while simultaneously meeting ecosystem or landscape level goals. Results from this research suggest that several economically feasible alternatives exist for any one set of landowner and ecosystem or landscape level goals. Most of these options also will enhance habitat suitability for selected wildlife species. Landowners can select the alternative that maximizes financial yields while meeting ecosystem goals. Results suggest that integrated expert systems such as FOREX can be used in ecosystem or landscape level planning. A methodology for assessing current timber supplies and product demands was developed. The methodology uses U.S. Forest Service forest inventory and analysis data, local forest industry production information, and a stump-to-mill cost production model. The methodology was applied to a case study of the Jefferson National Forest market area. Results suggest that the Jefferson National Forest market area can sustain itself from the economically available supply at current annual consumption levels for about 70 years. The methodology should be valuable to forest planners and land managers. Results of this research have been presented to resource managers, policy makers, loggers, and other researchers through publications, symposia, and other technology transfer outlets.

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**Problem 2**                      **Inadequate methods to plan/carry out multiproduct harvest/util. of E. hardwood on steep terrain**  
**FY 96 Research Attainments**

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**Publications**

**Cooperative**

Huyler, Neil K.; LeDoux, Chris B. 1996. Cut-to-length harvesting on a small woodlot in New England: a case study. In: Blinn, Charles R. and Thompson, Michael A., eds. Planning and implementing forest operations to achieve sustainable forests: proceedings of joint meeting of Council on Forest Engineering and IUFRO; 1996 July 29-August 1; Marquette, MI. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station:

**Attainment**

A case study was conducted to evaluate the production, cost, and environmental impact of a small cut-to-length harvester with a forwarding system used on a small suburban woodlot. Results reported include: average productivity of the harvester and the forwarder, costs at two alternative product levels, and the degree of soil/site disturbance experienced. Results suggest that small cut-to-length systems can operate economically in small woodlots in suburban settings while maintaining acceptable environmental and aesthetic impact levels. Cut-to-length systems usually have a high machine rate cost, and sideslope and tree size limitations; however, they can operate profitably over a wide range of woodlots that require thinning as long as the woodlots contain multiproducts such as pulpwood, fuelwood, and some medium- to high-grade sawlogs. A delay free cycle time equation was developed for a small cable yarder, the Koller K300. The small yarder was studied in a northeastern woodlot. The equation can be used by planners considering using small cable logging systems to treat their woodlots. Results of this research have been presented to resource managers, policy makers, loggers, and other researchers through publications, symposia, and other technology transfer outlets.

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Northeastern Forest Experiment Station  
Resource Analysis Research  
Research Work Unit 4801

Forest Inventory and Analysis  
Peters, John R., Project Leader

FY 96 Research Attainments  
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Conduct periodic forest resources inventories and evaluations	RAR	1837	.2	16		
2. Conducting special analyses of specific resource issues and concerns	RAR	601	.8	13		4

## Problem 1

Conduct periodic forest resources inventories and evaluations  
FY 96 Research Attainments

## Publications

## Research Unit

Alerich, Carol L. 1996. Results of the 1993 forest inventory. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 3-11.

Alerich, Carol L.; Drake, David A. 1995. Forest statistics for New York 1980 and 1993. *Resour. Bull.* NE-132. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 249 p.

Drake, David A. 1996. Inventory design and limitations. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 12-13.

Hershey, Rachel, R.; Befort, William A. 1996. An airphoto guide for New England forest cover types: a stereo key in color infrared. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. *SAF Publ.* 96-01. Bethesda, MD: Society of American Foresters: 452-454.

McWilliams, William H.; Arner, Stanford L.; Wharton, Eric H.; Hershey, Rachel R. 1996. Ecoregion-scale monitoring and assessment: a Pennsylvania case study. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. *SAF publ.* 96-01. Bethesda, MD: Society of American Foresters: 461-462.

Wharton, Eric H.; Mullarkey, Kevin M.; Grant, Beverly R. 1996. Timber removals in New York. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 41-58.

Widmann, Richard H. 1996. A closer look at key species. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 22-32.

Widmann, Richard H. 1996. Forest resources of New York's Capitol District. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 142-148.

Widmann, Richard H. 1996. Forest resources of New York's Catskill Lower Hudson Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 156-162.

Widmann, Richard H. 1996. Forest resources of New York's Eastern Adirondack Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 149-155.

Widmann, Richard H. 1996. Forest resources of New York's Lake Plain Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 163-169.

Widmann, Richard H. 1996. Forest resources of New York's South-Central Highland Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 170-176.

Widmann, Richard H. 1996. Forest resources of New York's Southwest Highland Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 184-190.

Widmann, Richard H. 1996. Forest resources of New York's St. Lawrence/Northern Adirondack Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 177-183.

Widmann, Richard H. 1996. Forest resources of New York's Western Adirondack Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 190-197.

Widmann, Richard H. 1996. Pulpwood production in the Northeast: 1991, 1992, and 1993. Resour. Bull. NE-133. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 24 p.

## Attainment

A forest statistics report for New York was published that highlights changes in resource conditions between 1980 and 1993. The report found general improvement in conditions. As the area of forest land remained stable, forest land has shifted towards stands containing sawtimber-size trees, inventory volume has increased, and the net growth in inventory exceeds removals by a factor of three. Sugar maple and red maple account for nearly one-third of the total volume.

A Report on pulpwood output for the northeast region was published that covers 1991, 1992, and 1993. The report provides details on pulpwood production and consumption from roundwood by county, and on pulpwood chip production from manufacturing residues by state.

Field work for the 1995 inventory of Maine was completed in January 1996. Compilation of the results and publication of the results are expected early in the fall of 1996.

**Problem 2**

**Conducting special analyses of specific resource issues and concerns  
FY 96 Research Attainments**

**Publications**

**Research Unit**

Birch, Thomas W. 1996. Forest land parcelization and fragmentation. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 98-110.

Birch, Thomas W. 1996. Private forest landowners of the United States, 1994. Resour. Bull. NE-134. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 183 p.

Birch, Thomas W. 1996. Private forest landowners of the United States, 1994. In: Baughman, Melvin J., ed. Proceedings of symposium on nonindustrial private forests: learning from the past, prospects for the future; 1996 February 21-24; Washington, DC. St. Paul, MN: University of Minnesota, Minnesota Extension Service: 10-20.

Birch, Thomas W. 1996. Private ownership trends in New York. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 14-21.

Gansner, David A.; King, Susan L.; Arner, Stanford L.; Drake, David A. 1996. Mapping shifts in the relative stocking of tree species. Northern Journal of Applied Forestry. 13 (2): 92-95.

Hershey, Rachel R. 1996. Understanding the spatial distribution of tree species in Pennsylvania. In: Mowrer, H. Todd; Czaplewski, Raymond L.; Hamre, R.H.; eds. Spatial accuracy assessment in natural resources and environmental sciences: second international symposium; 1996 May 21-23; Fort Collins, CO. Gen. Tech. Rep. RM-277. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 73-82.

Hershey, Rachel R.; Ramirez, Martin A.; Drake, David A. 1995. Exploring the geostatistical techniques available to create a map of tree species distribution: an example using forest inventory and analysis (FIA) data. In: Thompson, Joyce Elma, comp. Analysis in support of ecosystem management. Analysis workshop III; 1995 April 10-13; Fort Collins, CO. Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Analysis Center: 20-30.

Hershey, Rachel, R.; Birch, Thomas W. 1996. Method for identifying urban forest from forest inventory analysis (FIA) data. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 59-71.

King, Susan L. 1996. Neural networks vs. traditional techniques for forestry data. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 449-451.

King, Susan L.; Gansner, David A. 1995. Trends in relative stocking help locate forest health problems. In: Sessions, John; Brodie, J. Douglas, eds. Management systems for a global economy with global resource concerns. Proceedings of the 1994 symposium on systems analysis in forest resources; 1994 September 6-9; Pacific Grove, CA. Bethesda, MD: Society of American Foresters: 418-426.

McWilliams, William H.; Arner, Stanford L.; Birch, Thomas W.; Widmann, Richard H. 1996. Cutting activities in New York forest. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 33-40.

McWilliams, William H.; Stout, Susan L.; Bowersox, Todd W.; McCormick, Larry H. 1995. Adequacy of advance tree-seedling regeneration in Pennsylvania's forest. Northern Journal of Applied Forestry. 12 (4): 187-191.

McWilliams, William H.; White, Robert; Arner, Stanford L.; Nowak, Christopher A.; Stout, Susan L. 1996. Characteristics of declining forest stands on the Allegheny National Forests. Res. Note NE-360. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9 p.

#### Cooperative

Hodge, Sandra S.; Birch, Thomas W. Virginia NIPF landowners survey, 1991 and 1994. In: Baughman, Melvin J., ed. Proceedings of symposium on nonindustrial private forest: learning from the past, prospects for the future; 1996 February 21-24; Washington, DC. St. Paul, MN: University of Minnesota, Minnesota Extension Service: 454. Abstract.

Moulton, Robert J.; Birch, Thomas W. 1995. Southern private forest landowners: a profile. Forest Farmer Magazine. 54 (5): 44-46.

Moulton, Robert J.; Birch, Thomas W. 1996. Western forest landowners: a profile. National Woodlands. July: 14-16.

Stout, S.L.; Nowak, C.A.; Horsley, S.B.; Long, R.P.; White, R.; McWilliams, W. 1996. Forest health on Pennsylvania's Allegheny Plateau. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 435-436.

#### Attainment

A national study characterizing forest landowners in the U.S. was completed and results were compiled. Reports were published that summarize the findings for the southern and western region, as well as the nation. A national overview document with comprehensive tabular information is expected this Fall. The national overview will be followed by regional reports.

The general issue of forest health was addressed in publications on forest decline, forest regeneration, and an overview paper on forest health on the Allegheny Plateau of Pennsylvania. It was found that forest decline is having a significant impact on the Allegheny National Forest and sugar maple in particular. A study quantifying regeneration in Pennsylvania indicated low levels of advance regeneration in understory of Pennsylvania's forests. Analysis of forest resources using relative stocking continues with the publication of a paper on mapping shifts in relative stocking and a poster on identifying potential forest health issues by tracking trends in relative stocking over time.

A variety of poster presentations addressed techniques for analyzing forest resources in the spatial dimension, applications for neural networks in forestry, and guidelines for identifying New England cover types from aerial photographs.



Northeastern Forest Experiment Station  
Resource Analysis Research  
Research Work Unit 4803

Analysis of Domestic and International Hardwood Product Markets  
West, Cynthia D., Project Leader

FY 96 Research Attainments  
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Explain the interrelationships among domestic markets for hardwood products	RAR	158	1.0	3	1	
2. Develop more detailed information on int'l. hardwood products trade and describe impact	RAR	127	.7	3	1	2
3. Market-based decision making tools which can be used by hardwood processors and rural land owners	RAR	32	.3	4		1

**Problem 1**

**Explain the interrelationships among domestic markets for hardwood products**  
**FY 96 Research Attainments**

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**Publications****Research Unit**

Engle, Catherine A. 1996. Factors influencing material substitution in the United States pallet industry. In: Dolan, J. Daniel; Riegel, Angela, eds. Proceedings, environmental issues affecting the forest products industries in the Eastern United States; 1994 August 24-26; Baltimore, MD. Gen. Tech. Rep. NE-219. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 119-121.

Nolley, Jean W. 1995. Bulletin of hardwood market statistics: first, second, and third quarters-1994. Res. Note NE-359. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 21 p.

Scheerer, Catherine Engle; Bush, Robert J.; West, Cynthia D. 1996. The use of substitute material pallets for grocery distribution. Forest Products Journal. 46 (2): 29-36.

**Extramural**

Romig, Robert L. 1996. Characteristics of innovativeness among dimension and millwork firms in Kentucky, Ohio, Pennsylvania, and West Virginia. In Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 16. Abstract.

**Attainment**

Assessment of hardwood demand and use continues to be important in the eastern region of the United States. The pallet industry is the single largest user of hardwood lumber and cants at between 40 and 45% of production. Material use in the pallet industry is changing as producers and consumers evaluate and switch to alternative materials. The grocery distribution industry is the single largest user of standardized wooden pallets. Recent shifts to plastic pallets in closed loop systems and corrugated paperboard pallets for one way use have the potential to change traditional low-grade hardwood use patterns in the near future. The number of grocery distributors planning to use some plastic pallets is estimated to increase from 22% in 1992 to 37% by 1997. Regional assessment of hardwood demand and use is growing in importance to forest management planning agencies. An assessment of the demand and supply of hardwood resources within the market area of the Jefferson National Forest by industry segments provides NFS decision makers with important information on current and future management strategies. Segmenting demand and supply by type and quality revealed that low-grade supplies were more than adequate to meet market demands for wood under different economic scenarios. However, high-quality sawtimber supplies were inadequate to meet future demands in the region.

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<b>Problem 2</b>	<b>Develop more detailed information on int'l. hardwood products trade and describe impact</b>
	<b>FY 96 Research Attainments</b>

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**Publications**

<b>Research Unit</b>	Hansen, Bruce G.; Worthington, Virginia; West, Cynthia D. 1996. The state of origin of U.S. hardwood log and lumber exports. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 47. Abstract.
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	West, Cynthia D.; Hansen, Bruce. 1996. Forest resource issues and the sustainability of hardwood resource supplies. In: 1st annual Asian hardwood market seminar; 1996 June 7; Hong Kong. Washington, DC: American Hardwood Export Council: 16 p.
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	West, Cynthia D.; Hansen, Bruce. 1996. Trends in furniture consumption and industry development in Pacific Rim countries with special reference to the USA, Japan and China. In: Successful marketing through improved technology, quality & design: seminar on furniture marketing; 1996 March 8-9; Kuala Lumpur, Malaysia. Kuala Lumpur, Malaysia: Malaysian Timber Industry Board: 31 p.
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<b>Cooperative</b>	Blatner, Keith A.; Lee, Sang-Min; Chapman, Roger C.; Hansen, Bruce. 1996. The Korean market for temperate hardwoods: a comparison of trade statistics. Northern Journal of Applied Forestry. 13 (2): 59-67.
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	Smith, Paul M.; Michael, Judd H.; West, Cynthia D. 1995. Objective-oriented strategies for international furniture market participants. Taiwan Forest Products Journal. 14 (1): 166-184.
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<b>Extramural</b>	Emanuel, David M. 1995. HDC export report. Harrisburg, PA: Pennsylvania Hardwoods Development Council. 5 p.
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(Provided export data for report.)

**Attainment**

Export demand for U.S. hardwood lumber continues to be a major use of our hardwood resources at approximately 12% of production. This is due in large part to the fact that the United States is the single largest producer of temperate hardwoods. An analysis of European import patterns over the last two decades reveals that in several European countries there has been a significant shift in imports of tropical versus temperate logs and lumber, after controlling for price. This is the first indication that environmental concerns may promote an increase in demand for well-managed temperate hardwood wood resources from overseas markets. Export demand increased in 1995 by approximately 9% over 1994 exports by volume. This increase in demand came primarily from Asian countries and China which increased imports by 54%. The growth in demand from this region is due to the tremendous increase in furniture manufacturing capacity. Furniture production in this region is expected to continue to grow due to shifts in production from Japan, Taiwan, and the United States.

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**Problem 3**                      **Market-based decision making tools which can be used by hardwood processors and rural land owners**  
**FY 96 Research Attainments**

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**Publications**

**Research Unit**

Araman, Philip A.; West, Cynthia D. 1996. Announcing...the Hardwood Utilization Consortium. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 47. Abstract.

Araman, Philip A.; West, Cynthia D. 1996. Innovative and coordinated solutions for the hardwood industry: the hardwood utilization consortium. In: 24th annual hardwood symposium: putting research to work in the hardwood industry: new technology available today; 1996 May 8-11; Cashiers, NC. Memphis, TN: National Hardwoods Lumber Association: 6 p.

Lawson, Penny S.; Thomas, R. Edward; Walker, Elizabeth S. 1996. Optigrami V2 Users Guide. Gen. Tech. Rep. NE-222. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 46.

West, Cynthia D.; Cooper, Juett R. 1996. Marketing and technology--do they pay? In: 24th annual hardwood symposium: putting research to work in the hardwood industry: new technology available today; 1996 May 8-11; Cashiers, NC. Memphis, TN: National Hardwoods Lumber Association: 14 p.

**Cooperative**

Bick, Steven; Haney, Jr., Harry L.; West, Cynthia D. 1996. Profiles of conservation easements on forest land in northern New York. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 23. Abstract.

**Attainment**

Efficient and effective use of hardwood resources is dependent on a users ability to make sound allocation decisions that maximizes both utilization and value of the resource. A computer program was developed to be used on a personal computer to assist hardwood lumber allocation decisions by producers. The program determines the least-cost lumber grade mix required to produce a cutting order for clear parts from rough lumber in a crosscut-first rough mill operation. The program optimizes for species graded under standard National Hardwood Lumber Association grade rules. Output information includes gross volume of lumber required in each lumber grade, estimated production cost, board footage of parts generated, percent yield, and range of costs within each lumber grade for which the given solution is valid.

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**Northeastern Forest Experiment Station  
Resource Analysis Research  
Research Work Unit 4805**

**Enhancing the Performance and Competitiveness of the U.S. Hardwood Industry  
Luppold, William G., Project Leader**

**FY 96 Research Attainments  
Research Work Unit Summary**

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. An Analysis of the Structure, Conduct, and Performance of the Various Hardwood Product	RAR	43	.4	8		
2. Alternative Intervention Approaches to Remedy Externalities from Production/Processing Timber	RAR	54	.5			
3. Explore Strategies That Help Hardwood Processing Firms and Industries to Remain Competitive	RAR	11	.1	2		

Problem 1

An Analysis of the Structure, Conduct, and Performance of the Various Hardwood Product

FY 96 Research Attainments

Publications

Research Unit

Luppold, William. 1996. Regional differences in red oak lumber prices. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 43. Abstract.

Luppold, William. 1996. Structural changes in the Appalachian sawmilling industry. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 43. Abstract.

Luppold, William. 1996. An explanation of hardwood lumber pricing. *Forest Products Journal*. 46 (5): 52-55.

Luppold, William. 1996. Structural changes in the central Appalachian hardwood sawmilling industry. *Wood and Fiber Science*. 28 (3): 346-355.

Luppold, William G. 1995. Regional differences in the eastern hardwood sawmilling industry. *Forest Products Journal*. 45 (10): 39-43.

Luppold, William G. 1996. A comparison of the Appalachian and southern hardwood sawmill industry. In: Caulfield, Jon P.; Bullard, Steven H., eds. *A world of forestry: proceedings of the 25th annual southern forest economics workshop*; 1995 April 15-19; New Orleans, LA. Starkville, MS: Mississippi State University, Department of Forestry: 219-227.

Luppold, William G.; Baumgras, John E. 1995. Price trends and relationships for red oak and yellow-poplar stumpage, sawlogs, and lumber in Ohio: 1975-1993. *Northern Journal of Applied Forestry*. 12 (4): 168-173.

Luppold, William G.; Dempsey, Gilbert P. 1996. Is eastern hardwood sawtimber becoming scarcer? *Northern Journal of Applied Forestry*. 13 (1): 46-49.

Attainment

Over half of the hardwood lumber produced in the Eastern United States is manufactured in the eight states that comprise the Central Appalachian region. Over the last 25 years the number of sawmills in this region has declined as total production has increased as new technology and better roads have caused economies of scales and greater industry concentration. Still this increase in industry concentration has reduced competition in either the log or lumber markets. One indicator that increased industry competition has not reduced competition in the log and stumpage markets is the fact that price of higher grade logs has been increasing faster than lumber prices, and stumpage prices have been increasing faster than log prices. Many sawmill operators attribute the increase cost of lumber and logs to reduce sawtimber supplies. However, Forest Service estimates of increasing inventories of sawtimber contradict industries assertions of reduced sawtimber supplies. An examination of these two contradictory statements found no single reason for the difference in opinion, but forest industry draws their conclusion from specific situations confined to finite procurement area while Forest Survey statistics are based on aggregated data. An examination of lumber prices found that green lumber prices reported by the two major price reporting services are conditional and can change given changing market conditions. Larger sawmills also tend to provide a greater range of products than smaller mills.

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**Problem 2**                      **Alternative Intervention Approaches to Remedy Externalities from  
Production/Processing Timber  
FY 96 Research Attainments**

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**Publications**

none

**Attainment**

Although there is no attainment to report in problem area 2 in FY96, there were two active areas of research. Analysis of the impact of storm water runoff regulations on the forest products industry found great variation in the way these regulations are implemented. While some states such as Georgia and Mississippi have developed procedures that allow sawmills to easily comply with regulations, other states have developed regulations that require considerable paperwork and constant water monitoring. Examination of regulations affecting the wood treating industry found that this industry has much more stringent storm water quality requirements than other SIC 24 industries. However, there is again great variation in regulations between states. The second area of regulatory research being examined in FY 96 is the impact of Forest Service timber policy on the hardwood lumber industry. Preliminary research indicates that the quality of timber on much of the National Forests lands is higher than on adjoining private land. Furthermore, National Forests contain a high proportion of the species that are most desired by hardwood lumber users. Still, actual sawtimber cut on National Forests has declined by 50 percent since the mid-1980's.

Problem 3

Explore Strategies That Help Hardwood Processing Firms and Industries to Remain Competitive  
FY 96 Research Attainments

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Publications

Research Unit

Luppold, William. 1996. The relationship between structural change and lumber price. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 27. Abstract.

Luppold, William G. 1995. Making utilization and marketing research serve producers and users of hardwood lumber. In: Lowery, Glenn; Meyer, Dan, eds. Advances in hardwood utilization: following profitability from the woods through rough dimension. Proceedings of the 23rd annual hardwood symposium; 1995 May 17-20; Cashiers, NC. Memphis, TN: National Hardwood Lumber Association: 1-4.

Attainment

The hardwood lumber and related industries are composed of numerous small facilities that are, for the most part, privately owned. Because most primary hardwood processors are small business, they have little funds for research and development activities that will help ensure continual competitiveness. Therefore, the public sector has, for many years, been assisting the hardwood industry by developing utilization and marketing research. Unfortunately, not all research completed by public agencies consider the barriers to implementing new technologies or understand the needs of the industries. Some of the most critical issues that affect technology adoption is the cyclical market, multiple input/multiple output production processes, product differentiation, and the fact that the industry is cautious taking on new debt. The hardwood lumber industry also has faced nearly continuous changes in the markets they serve and the resource market they depend on for material. In response to these changes, the industry has continually changed the way their products are manufactured and priced.

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Northeastern Forest Experiment Station  
Resource Analysis Research  
Research Work Unit 4952

Structure and Function of Urban Forests  
Rowntree, Rowan A., Project Leader

FY 96 Research Attainments  
Research Work Unit Summary

Problem number and title	Functional account	Current funding	Current staffing	Research Outputs		
				Research unit	Extra- mural	Cooper- ative
		<i>thousand dollars</i>	<i>scientist years</i>			
1. Understand How Presettlement Forest Structure and Function is Changing as a Result of Urbanization	RAR	440	2.0	8	6	5
2. Understand Changes in Energy, Water, and Pollutant Flux Associated with Land Use Changes	RAR	612	2.0	3	3	5

<b>Problem 1</b>	<b>Understand How Presettlement Forest Structure and Function is Changing as a Result of Urbanization</b>
	<b>FY 96 Research Attainments</b>

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**Publications**

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|----------------------|---|
| <b>Research Unit</b> | <p>McHale, P.J.; Mitchell, M.J. 1996. Disturbance effects on soil solution chemistry due to heating cable installation. <i>Biology and Fertility of Soils</i>. 22: 40-44.</p> <p>McHale, Patrick J.; Mitchell, Myron J.; Raynal, Dudley J.; Bowles, Francis P. 1996. Increasing soil temperature in a northern hardwood forest: effects on elemental dynamics and primary productivity. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. <i>Proceedings, 1995 meeting of the Northern Global Change Program</i>; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 146-152.</p> <p>Pouyat, R.V.; Groffman, P.M.; Carreiro, M.M.; Bohlen, P.; Parmelee, R.W. 1996. Temperature and earthworm effects on C and N dynamics in oak stands along an urban-rural land use gradient. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. <i>Proceedings, 1995 meeting of the Northern Global Change Program</i>; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 208. Abstract.</p> <p>(Presentation abstract.)</p> <p>Pouyat, Richard V. 1996. Review of "Urban forest landscapes-integrating multidisciplinary perspectives." <i>Northwest Science</i>. 70(2): 187-188.</p> <p>(Book review.)</p> <p>Pouyat, Richard V. 1996. Urban environmental effects on terrestrial ecosystems. In: <i>Paved to protected: restoration in the urban/rural context</i>. Society for Ecological Restoration 1996 international conference; 1996 June 17-22; New Brunswick, NJ. Madison, WI: Society for Ecological Restoration: 84. Abstract.</p> <p>(Presentation abstract. No proceedings.)</p> <p>Pouyat, Richard V.; Bohlen, Patrick V.; Eviner, Valerie; Carreiro, Margaret M.; Groffman, Peter M. 1996. Short and long-term effects of earthworms on N dynamics in forest soils. <i>Supplement to Bulletin of the Ecological Society of America</i>, 77(3): 359. Abstract.</p> <p>Zipperer, W.C.; Grove, J.M.; Neville, L.R. 1995. Ecosystem management in urban environments. In: Kollin, Cheryl; Barratt, Michael, eds. <i>Proceedings of the 7th national urban forest conference</i>; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 6-9.</p> <p>Zipperer, Wayne C. 1996. Future research directions for managing and restoring urban woodlands. In: <i>Paved to protected: restoration in the urban/rural context</i>. Society for Ecological Restoration 1996 international conference; 1996 June 17-22; New Brunswick, NJ. Madison, WI: Society for Ecological Restoration: 104. Abstract.</p> <p>(Presentation abstract. No proceedings.)</p> |
| <b>Cooperative</b>   | <p>Bohlen, Patrick J.; Pouyat, Richard V.; Eviner, Valerie; Groffman, Peter M. 1996. Short and long-term effects of earthworms on nitrous oxide fluxes in forest soils. <i>Supplement to Bulletin of the Ecological Society of America</i>. 77(3): 43. Abstract.</p> <p>Grove, J. Morgan; Zipperer, Wayne C. 1996. Social area index for landscape analysis. In: <i>Integration of cultural and natural ecosystems across landscapes: application of the science</i>. 11th annual landscape ecology symposium of International Association for Landscape Ecology; 1996 March 26-30; Galveston, TX. College Station, TX: Texas A&amp;M University: 52-53. Abstract.</p> <p>Grove, J.M.; Zipperer, W.C.; Neville, L.R. 1995. Social indicators and classification for urban ecosystem management. In: Kollin, Cheryl; Barratt, Michael, eds. <i>Proceedings of the 7th national urban forest conference</i>; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 13-16.</p>   |

McDonnell, M.J.; Pickett, S.T.A.; Pouyat, R.V.; Zipperer, W.C. 1995. Urban-rural ecological gradients: a new perspective for urban forestry. In: Kollin, Cheryl; Barratt, Michael, eds. Proceedings of the 7th national urban forest conference; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 22-24.

Neville, L.R.; Grove, J.M.; Zipperer, W.C. 1995. Ecological classification for urban ecosystem management. In: Killin, Cheryl; Barratt, Michael, eds. Proceedings of the 7th national urban forest conference; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 10-12.

#### Extramural

Grove, J.M. 1996. Cause and consequence: the social dimension of urban ecological restoration. In: Paved to protected: restoration in the urban/rural context. Society for Ecological Restoration 1996 international conference; 1996 June 17-22; New Brunswick, NJ. Madison, WI: Society for Ecological Restoration: 58. Abstract.

(Presentation abstract. No proceedings. Unit partially funded this research.)

Grove, Jonathan Morgan. 1996. The relationship between patterns and processes of social stratification and vegetation of an urban-rural watershed. New Haven, CT: Yale University. 109. Ph.D. dissertation.

(Unit partially funded student's research.)

Nilon, Charles. 1996. Wildlife conservation issues in ecological restoration of urban areas. In: Paved to protected: restoration in the urban/rural context. Society for Ecological Restoration 1996 international conference; 1996 June 17-22; New Brunswick, NJ. Madison, WI: Society for Ecological Restoration: 79. Abstract.

(Presentation abstract. No proceedings. Unit partially funded this research.)

SNEP Science Team and Special Consultants. 1996. Sierra Nevada Ecosystem Project, final report to Congress. Volume I: assessment summaries and management strategies. Wildland Resour. Cent. Rep. 36. Davis, CA: University of California Centers for Water and Wildland Resources: 209 p.

(Rowan Rowntree was 1 of 4 authors synthesizing results from 60 technical/scientific reports from members of the Science Team and Special Consultants. Rowntree spent 2-years working on this Congressionally mandated study.)

Steinberg, David A. 1995. Earthworm activity and nitrogen mineralization rates along an urban-rural land use gradient. In: Undergraduate research reports: summer 1991, 1992, and 1993. Occas. Publ. 10. Millbrook, NY: Institute of Ecosystem Studies: 152-157.

(Pouyat, acting as mentor scientist, guided student's work and reviewed the manuscript.)

Wildland Resources Center. 1996. Summary of the Sierra Nevada Ecosystem Project report. Wildland Resour. Cent. Rep. 39. Davis, CA: University of California, Centers for Water and Wildland Resources: 22 p.

(Rowan Rowntree was 1 of 4 authors synthesizing results from 60 technical/scientific reports from members of the Science Team and Special Consultants. Rowntree spent 2-years working on this Congressionally mandated study.)

Attainment

In both problems, advances were made in assessing models of relationships among ecological and social factors in managing ecosystems affected by urbanization. In the New York, Baltimore, and Sierra Nevada studies, we (1) developed methods for assessing systems-level scientific knowledge, and (2) evaluated forms of discourse among scientists, field professionals, and citizens in the conduct of each study; discourse having the potential for informing science-based management of ecosystems disturbed by urbanization and having two attributes: (1) the hierarchy of systems in time and space (e.g. integrating soil-earthworm relations into ecological-social systems), and (2) ways of confronting complexity and large measures of uncertainty (e.g. experimenting with, and evaluating, adaptive management). In the Sierra Nevada Study, seminars between scientists and non-scientists during the course of the two-year bioregional analysis allowed quick understanding of the complex 60 volume final report which relates internal ecosystem processes with external processes of drought, fire, climate change, settlement, and urbanization. This approach allowed for early modifications to county, state, and federal levels of land management policy. In each of the New York City, Baltimore and Sierra Nevada studies, the significance of the work emerges from the involvement of professionals and citizens in ways that enable them to grasp and test knowledge, premises, assumptions, and logic that forms the model structure and function.

**Problem 2**                      **Understand Changes in Energy, Water, and Pollutant Flux Associated with Land Use Changes**  
**FY 96 Research Attainments**

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**Publications**

- Research Unit**
- Heisler, Gordon M.; Grant, Richard H.; Gao, Wei. 1996. UVB and PAR in the vicinity of urban trees and buildings. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & aerobiology; 1996 January 28-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 460-461.
- Heisler, Gordon M.; Grant, Richard H.; Grimmond, Sue; Souch, Catherine. 1995. Urban forests-cooling our communities? In: Kollin, Cheryl; Barratt, Michael, eds. Proceedings of the 7th national urban forest conference; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 31-34.
- Nowak, David J. 1995. Trees pollute? a "TREE" explains it all. In: Kollin, Cheryl; Barratt, Michael, eds. Proceedings of the 7th national urban forest conference; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 28-30.
- Cooperative**
- Docteur, Michelle M.; Heisler, G.M. 1996. Ultraviolet radiation in urban environments and potential effects on human health. In: Proceedings of spotlight on research '96 undergraduate and graduate research symposium: 1996 April 19; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry. Abstract.
- (Poster abstract.)
- Gao, Wei; Grant, Richard H.; Heisler, Gordon M. 1996. Spectral radiative properties of various tree species in ultraviolet wavelengths and irradiance modeling implications. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & aerobiology; 1996 January 28-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 417-418.
- Grant, Richard H.; Gao, Wei; Heisler, Gordon M. 1996. The distribution of photosynthetically-active radiance and its influence on shadowband corrections under clear and translucent overcast conditions. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & aerobiology; 1996 January 28-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 157-160.
- Hansen, Lance Darrick; Heisler, G.M. 1996. Computer simulation studies of tree effects on residential energy use. In: Proceedings of spotlight on research '96 undergraduate and graduate research symposium. 1996 April 19; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry. Abstract.
- (Poster abstract.)
- McPherson, E. Gregory; Nowak, David; Heisler, Gordon; Grimmond, Sue; Souch, Catherine; Grant, Rich. 1995. Results of the Chicago urban forest climate project. In: Kollin, Cheryl; Barratt, Michael, eds. Proceedings of the 7th national urban forest conference; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 85-88.
- (Authors Name: (7) Rowntree, Rowan)
- Extramural**
- Grant, Richard H. 1996. Characterization of UVA and UVB irradiance sensors. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & aerobiology; 1996 January 18-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 169-172.
- (Unit partially funded this research. Heisler reviewed manuscript.)
- Grimmond, C.S.B.; Oke, T.R.; Spronken-Smith, R.; Jaurequi, E.; Souch, C.; Newton, T. 1996. Heat storage in urban areas. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & aerobiology; January 28-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 466-469.

(Author(s) name: (7) King, T.S. (8) Vogt, J. (9) Hubble, M.D. Unit partially funded this research.)

Luley, Christopher J. 1995. Funding urban forestry: air pollution and carbon credits. In: Kollin, Cheryl; Barratt, Michael, eds. Proceedings of the 7th national urban forest conference; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 194-197.

(Nowak helped conceive study and worked with cooperater in finishing the project.)

**Attainment**

Advances were made in assessing scientific and public understanding of relationships among factors affecting how trees and forests influence air quality and the human thermal and radiation environment. Our assessment concludes that current scientific understanding is unable to model interactions—under different air temperature conditions—among tree-forest production of polluting volatile organic hydrocarbons and tree-forest removal of polluting sulfur-nitrogen oxides, ozone, and particulates with the precision that can support management-scale decisions, based on conference and symposia feedback. Advances were also made in measuring and analyzing irradiance in ultraviolet-B (UVB) and photosynthetically active radiation (PAR) wavelengths at points near or in tree shade and also near a building in a suburban area. The UVB is important because UVB exposure has been linked to skin cancers and cataracts, PAR was included as it is nearly equivalent to visible light. Differences between PAR and UVB sky diffuse fractions and differences in reflection cause differences in the fractions of these solar radiation components that penetrate to pedestrian levels in urban environments. In visible shade where there is significant view of the sky, relative UVB levels are generally much higher than relative PAR levels. Just outside visible shade, UVB relative irradiance is generally lower than relative PAR. Thus, design to control UVB should consider sky view.

## **Part II: Bibliography**

**Forest  
Environment  
Research**

- Aber, John D.; Ollinger, Scott V.; Federer, C. Anthony; Reich, Peter B.; Goulden, Michael L.; Kicklighter, David W. 1995. Predicting the effects of climate change on water yield and forest production in the northeastern United States. *Climate Research*. 5: 207-222.
- Angradi, Ted R. 1996. Inter-habitat variation in benthic community structure, function, and organic matter storage in 3 Appalachian headwater streams. *Journal of the North American Benthological Society*. 15 (1): 41-63.
- Angradi, Ted R.; Vinson, Mark R. 1995. Aquatic macroinvertebrate monitoring on national forests and Bureau of Land Management districts. *Bulletin of the North American Benthological Society*. 12 (3): 389-398.
- Bailey, Scott W.; Hornbeck, James W.; Driscoll, Charles T.; Gaudette, Henri E. 1996. Calcium inputs and transport in a base-poor forest ecosystem as interpreted by Sr isotopes. *Water Resources Research*. 32 (3): 707-719.
- Brooks, Robert T. 1996. Assessment of two camera-based systems for monitoring arboreal wildlife. *Wildlife Society Bulletin*. 24 (2): 3 p.
- Campbell, John. 1996. Processes affecting the acid-base status of surface waters in the Lye Brook Wilderness, Vermont. Durham, NH: University of New Hampshire. 120. M.S. thesis.
- Cook, Stephen P.; Smith, Harvey R.; Hain, Fred P.; Hastings, Felton L. 1995. Predation of gypsy moth (Lepidoptera: Lymantriidae) pupae by invertebrates at low small mammal population densities. *Environmental Entomology*. 24 (5): 1234-1238.
- Daigle, John J.; Muth, Robert M.; Zwick, Rodney R.; Glass, Ronald J. 1996. The importance of social networks among trappers in six northeastern states. In: *Proceedings, 6th international symposium on society and resource management: social behaviour, natural resources, and the environment; 1996 May 18-23; University Park, PA. University Park, PA: The Pennsylvania State University: 45. Abstract.*
- Daigle, John J.; Muth, Robert M.; Zwick, Rodney R.; Glass, Ronald J. 1996. Trapping-related values and motivations among trappers in the northeastern United States: a factor-analytic study. In: *Proceedings, 6th international symposium on society and resource management: social behavior, natural resources, and the environment; 1996 May 18-23; University Park, PA. University Park, PA: The Pennsylvania State University: 47. Abstract.*
- Daigle, John J.; Muth, Robert M.; Zwick, Rodney R.; Glass, Ronald J. 1995. Social values and motivations of trappers in six northeastern states. In: Thompson, Jerrilyn Lavarre; Lime, David W.; Gartner, Bill; Sames, Wayne M., comps. *Proceedings of the 4th international outdoor recreation & tourism trends symp. and 1995 national recreation resources planning conference; 1995 May 14-17; St. Paul, MN. St. Paul, MN: University of Minnesota, College of Natural Resources and Minnesota Extension Service: 531-535.*
- DeGraaf, Richard M. 1995. Nest predation rates in managed and reserved extensive northern hardwood forests. *Forest Ecology and Management*. 79: 227-234.
- DeGraaf, Richard M.; Rappole, John H. 1995. Neotropical migratory birds: natural history, distribution, and population change. Ithaca, NY: Cornell University Press. 676.
- Dennis, Donald F.; Kuentzel, Walter F.; Tritton, Louise M.; Wang, Deane. 1996. Wetland externalities: implications for policy and decision-making. In: Dawson, Chad P., comp. *Proceedings of the 1995 northeastern recreation research symposium; 1995 April 9-11; Saratoga Springs, NY. Gen. Tech. Rep. NE 218. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 148-151.*
- Eagar, Christopher; Nicholas, N.S. 1996. Old-growth spruce-fir in the southern Appalachians: stand dynamics and tree condition over an eleven year period. *Supplement to Bulletin of the Ecological Society of America*. 77(3): 124. Abstract.
- Echelberger, Herbert E. 1996. Forest Service research on the human dimensions of ecosystem management. In: *Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 344-350.*

- Edwards, Pamela J. 1995. Chapter 2. Site characteristics. In: Effects of diflubenzuron on non-target organisms in broadleaf forested watersheds in the Northeast. FHM-NC-05-95. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area, State and Private Forestry: 6-12.
- Federer, C.A.; Vorosmarty, C.; Fekete, B. 1996. Intercomparison of methods of calculating potential evaporation in regional and global water balance models. *Water Resources Research*. 32 (7): 2315-2321.
- Gilliam, Frank S.; Adams, Mary Beth; Yurish, Bradley M. 1996. Ecosystem nutrient responses to chronic nitrogen inputs at Fernow Experimental Forest, West Virginia. *Canadian Journal of Forest Research*. 26 (4): 196-205.
- Gilliam, Frank S.; Turrill, Nicole L; Adams, Mary Beth. 1995. Herbaceous-layer and overstory species in clear-cut and mature central Appalachian hardwood forests. *Ecological Applications*. 5 (4): 947-955.
- Glass, Ronald J.; More, Thomas A.; Echelberger, Herbert E. 1995. Natural resources and the quality of life in rural New England. In: Managing forests to meet peoples' needs: proceedings of the 1994 Society of American Foresters/Canadian Institute of Forestry convention; 1994 September 18-22; Anchorage, AK. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 327-328.
- Glass, Ronald J.; Muth, Robert M.; More, Thomas A.; Kruse, Jack. 1995. Assessing developmental impacts on subsistence fishing: complications attributable to a mixed economic system. *Society and Natural Resources*. 8: 431-442.
- Glass, Ronald J.; Walton, Gerald S. 1995. Recreation use of Upper Pemigewasset and Swift River Drainages, New Hampshire. Res. Pap. NE-701. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.
- Griesemer, Sara J.; DeGraaf, Richard M.; Fuller, Todd K. 1994. Effects of excluding porcupines from established winter feeding trees in central Massachusetts. *Northeast Wildlife*. 51: 29-33.
- Grove, J. Morgan; Zipperer, Wayne C. 1996. Social area index for landscape analysis. In: Integration of cultural and natural ecosystems across landscapes: application of the science. 11th annual landscape ecology symposium of International Association for Landscape Ecology; 1996 March 26-30; Galveston, TX. College Station, TX: Texas A&M University: 52-53. Abstract.
- Grove, J.M. 1996. Cause and consequence: the social dimensions of urban ecological restoration. In: Paved to protected: restoration in the urban/rural context. Society for Ecological Restoration 1996 international conference; 1996 June 17-22; New Brunswick, NJ. Madison, WI: Society for Ecological Restoration: 58. Abstract.
- Hallett, R.A.; Hornbeck, J.W. 1996. Cation depletion in New England forests. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 404-405. Poster.
- Hallett, Richard A. 1996. Foliar and soil nutrient relationships in red oak and white pine forests. Durham, NH: University of New Hampshire. 93. Ph.D. dissertation.
- Hastings, Felton L.; Hain, Fred P.; Smith, Harvey R.; Odell, Thomas M.; Cook, Stephen P. 1995. Natural enemies of the gypsy moth at the leading edge of its invasion into the southern U.S. In: Hain, Fred P.; Salom, Scott M.; Ravlin, William F.; Payne, Thomas L.; Raffa, Kenneth F., eds. Behavior, population dynamics and control of forest insects. Proceedings of the IUFRO joint conference; 1994 February 6-11; Maui, HI. Wooster, OH: The Ohio State University, Ohio Agricultural Research and Development Center: 474-490.
- Hastings, Fenton L.; Hain, Fred P.; Smith, Harvey R.; Odell, Thomas M. 1995. Natural enemies of the gypsy moth at the leading edge of its invasion into the southern U.S. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 76. Abstract.
- Healy, William M. 1994. Ecosystem management: policies and procedures for effective implementation in the Northeast. *Northeast Wildlife*. 51: 81-89.

- Healy, William M. 1995. Wildlife use of oak forests. *Wildlife Habitats*. 11 (1): 1-2, 7.
- Hislop, J.E.; Hallett, R.A.; Hornbeck, J.W. 1996. Microwave digestion of forest soil and plant tissue samples. In: *Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME*. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 396-397. Poster.
- Karle, Kenneth F.; Edwards, Pamela J.; Major, Elaine B. 1996. Streambed disturbance during and after restoration of Glen Creek, Denali National Park, Alaska. In: McDonnell, Jeffrey J.; Stribling, James B.; Neville, L. Robert; Leopold, Donald J., eds. *Watershed restoration management: physical, chemical, and biological considerations*. Amer. Water Res. Assoc. symp. proceedings; 1996 July 14-17; Syracuse, NY. Herndon, VA: American Water Resources Association: 351-360.
- Kochenderfer, James N.; Helvey, J.D.; Patric, James H.; Kidd, William E., Jr. 1996. *Woodlot management: an introduction to water in the forest*. Morgantown, WV: West Virginia University, Extension Service. 28.
- Kochenderfer, James N.; Smith, H. Clay; Crews, Jerry T. 1996. Effects of fertilization on the growth and development of a Japanese larch plantation in West Virginia. Res. Pap. NE-700. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8.
- Kuentzel, Walter F.; Tritton, Louise M.; Dennis, Donald F.; Wang, Deane. 1996. Thinking about water quality management: social values, wetland ecology, and landowner practices. In: *Integrating social science and ecosystem management: a national challenge. Proceedings of national workshop of the conference on integrating social sciences and ecosystem management; 1995 December 12-14; Helen, GA*. [Place of publ. unknown]: [Publisher name unknown]: 186-194.
- Likens, G.E.; Driscoll, C.T.; Buso, D.C. 1996. Long-term effects of acid rain: response and recovery of a forest ecosystem. *Science*. 272: 244-246.
- Martin, C. Wayne. 1996. Water quality—an overview. In: *Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME*. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 121-126.
- Martin, C. Wayne; Hornbeck, James W. 1996. Sediment as a nonpoint source pollutant can be controlled during harvesting of northern hardwood forests. In: *Proceedings of the 6th federal interagency sedimentation conference; 1996 March 10-14; Las Vegas, NV*. [Place of publ. unknown]: [Publisher name unknown]: X-78-X-85.
- More, Thomas A. 1996. Values, conflicts, and moral dilemmas in trapping. In: *Proceedings, 6th international symposium on society and resource management: social behavior, natural resources, and the environment; 1996 May 18-23; University Park, PA*. University Park, PA: The Pennsylvania State University: 47. Abstract.
- More, Thomas A. 1996. Why definitional criticisms of ecosystem management don't hold water? In: Brissette, John C., comp. *76th winter meeting of the New England Society of American Foresters; 1996 March 20-23; Lowell, MA* [Place of publication unknown]: New England Society of American Foresters: 18. Poster Abstract.
- More, Thomas A.; Stanat, Petra; and Averill, James. 1996. Natural beauty. In: Brissette, John C., comp. *76th winter meeting of the New England Society of American Foresters; 1996 March 20-23; Lowell, MA*. [Place of publ. unknown]: New England Society of American Foresters: 16. Poster Abstract.
- More, Thomas A. 1996. Forestry's fuzzy concepts: an examination of ecosystem management. *Journal of Forestry*. 94 (8): 19-23.
- More, Tom; Steering Committee. 1996. 1995 April 9-11; Saratoga Springs, NY. Gen. Tech. Rep. NE-218. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 286 p.
- Pardo, L.H.; Driscoll, C.T. 1996. Critical loads for nitrogen deposition: case studies at two northern hardwood forests. *Water, Air, and Soil Pollution*. 89: 105-128.

- Pardo, L.H.; Driscoll, C.T.; Likens, G.E. 1995. Patterns of nitrate loss from a chronosequence of clear-cut watersheds. *Water, Air, and Soil Pollution*. 85: 1659-1664.
- Pardo, L.J. 1996. Response of natural abundance of  $^{15}\text{N}$  in forest soils to high nitrate loss following clearcutting. Supplement to Bulletin of the Ecological Society of America. 77(3): 340. Abstract.
- Pickens, Callie J.; Sharpe, William E.; Edwards, Pamela J. 1994. Early indicators of acidification: a whole-watershed approach to studying forest response. *Sch. of For. Resour. Annu. Rep. Vol. 10*. University Park, PA: The Pennsylvania State University, College of Agricultural Sciences. 7 p.
- Ries, Robert D.; Perry, Sue A. 1995. Potential effects of global climate warming on brook trout growth and prey consumption in central Appalachian streams, USA. *Climate Research*. 5: 197-206.
- Sadighi, Kay; DeGraaf, Richard M.; Danielson, William R. 1995. Experimental use of remotely-triggered cameras to monitor occurrence of timber rattlesnakes (*Crotalus horridus*). *Herpetological Review*. 26 (4): 189-190.
- Scott, J. Michael; Ables, Ernest D.; Edwards, Thomas C.; Eng, Robert L.; Gavin, Thomas A.; Healy, William M. 1995. Conservation of biological diversity: perspectives and the future for the wildlife profession. *Wildlife Society Bulletin*. 23 (4): 646-657.
- Skog, Kenneth; Green, David; Barbor, R. James; Baumgras, John; Clark, Alexander III; Mason, Andrew. 1995. Building partnerships to evaluate wood utilization options for improving forest health. In: Eskew, Lane G., comp. *Forest health through silviculture. Proceedings of the 1995 national silviculture workshop; 1995 May 8-11; Mescalero, NM*. Gen. Tech. Rep. RM-GTR-267. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 153-161.
- Smith, Harvey R.; Remington, Charles L. 1996. Food specificity in interspecies competition. *BioScience*. 46 (6): 436-447.
- Stevens, T. H.; Field, Martha K.; More, Thomas A.; Glass, Ronald J. 1994. Contingent valuation of rare and endangered species: an assessment. In: Ready, Richard, comp. *Benefits and costs transfer in natural resource planning*. West. Reg. Res. Publ. W-133. Lexington, KY: University of Kentucky, Department of Agricultural Economics: 471-487.
- Tajchman, S.J.; Kochenderfer, J.N.; Fu, H. 1996. Water and energy balance of a forested Appalachian watershed. In: Kohn, Michael; Gertner, George Z., eds. *Caring for the forest: research in a changing world. Statistics, mathematics and computers. Proceedings of the meeting of IUFRO XX World Congress; 1995 August 6-12; Tampere, Finland*. Birmensdorf, Switzerland: Swiss Federal Institute for Forest, Snow and Landscape Research: 33. Abstract.
- Tritton, Louise M.; Wade, Gary L. 1996. Evaluating biodiversity of land units: scale, diversity types, and stakes. In: *Integrating social science and ecosystem management: a national challenge. Proceedings, national workshop of the conference on integrating social sciences and ecosystem management; 1995 December 12-14; Helen, GA*. [Place of publ. unknown]: [Publisher name unknown]: 130-133.
- Twery, Mark J.; Gottschalk, Kurt W. 1996. Forest health: another fuzzy concept. *Journal of Forestry*. 94 (8): 20.
- Wade, Gary L.; Sanders, Laurie. 1996. Vascular floras of shelterwood cuts: comparisons with a suite of reference areas. Supplement to Bulletin of the Ecological Society of America. 77(3): 463. Abstract.
- Yokum, Kevin A.; Johnson, Brent R.; Tipton, R. Clif; Tarter, Donald C.; Angradi, Ted R. 1996. Leaf species selection by the shredding stoneflies *Peltoperla arcuata* and *Tallaperla maria* (Plecoptera: Peltoperlidae). In: *Proceedings of the West Virginia Academy of Science 1994: paper of the 69th annual session; 1994 April 23; Fairmont, WV*. Vol. 66. Morgantown, WV: West Virginia Academy of Science: 34-42.

**Forest  
Management  
Research**

- Aber, John; Magill, Alison; McNulty, Steven; Boone, Richard; Nadelhoffer, Knute; Downs, Morty; Hallett, Richard. 1996. Forest biogeochemistry and primary production altered by nitrogen saturation. Supplement to Bulletin of the Ecological Society of America. 77(3): 2. Abstract.
- Aber, John D.; Magill, Alison; McNulty, Steven G.; Boone, Richard D.; Nadelhoffer, Knute J.; Hallett, Richard A. 1995. Forest biogeochemistry and primary production altered by nitrogen saturation. *Water, Air and Soil Pollution*. 85: 1665-1670.
- Anderson, Mark G.; Sneddon, L.A.; Smith, M.L.; Carpenter, C. 1996. Relationships between a geophysical based land classification system. Supplement to Bulletin of the Ecological Society of America. 77(3): 12. Abstract.
- Arneth, A.; Kelliher, F.M.; Bauer, G.; Hollinger, D.Y.; Byers, J.N.; Hunt, J.E. 1996. Environmental regulation of xylem sap flow and total conductance of *Larix qmelinii* trees in eastern Siberia. *Tree Physiology*. 16: 247-255.
- Barrett, Hope R. 1996. Catalog of long-term research conducted within the USDA Forest Service, Northeastern Forest Experiment Station. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service; Northeastern Forest Experiment Station: 226. Abstract.
- Baumgras, John E.; Miller, Gary W.; LeDoux, Chris B. 1995. Economics of hardwood silviculture using skyline and conventional logging. In: Lowery, Glenn; Meyer, Dan, eds. Advances in hardwood utilization: following profitability from the woods through rough dimension. Proceedings of the 23rd annual hardwood symposium; 1995 May 17-20; Cashiers, NC. Memphis, TN: National Hardwood Lumber Association: 5-17.
- Bobola, Michael S.; Eckert, Robert T.; Klein, Anita S.; Stapelfeldt, Karen; Hillenberg, Kimberly A.; Gendreau, Steve B. 1996. Hybridization between *Picea rubens* and *Picea mariana*: differences observed between montane and coastal island populations. *Canadian Journal of Forest Research*. 26: 444-452.
- Bobola, Michael S.; Eckert, Robert T.; Klein, Anita S.; Stapelfeldt, Karen; Smith, Dirk E.; Guenette, Denis. 1996. Using nuclear and organelle DNA markers to discriminate among *Picea rubens*, *Picea mariana*, and their hybrids. *Canadian Journal of Forest Research*. 26: 433-443.
- Boerner, Ralph E.J.; Sutherland, Elaine Kennedy. 1996. Relative nitrogen mineralization and nitrification potentials in relation to soil chemistry in oak forest soils along a historical deposition gradient. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 167. Abstract.
- Brissette, John C.; Barnett, James P.; Jones, John P. 1996. Fungicides improve field performance of stored loblolly and longleaf pine seedlings. *Southern Journal of Applied Forestry*. 20 (1): 5-9.
- Brissette, John C., ed. 1996. Proceedings of the tree shelter conference. Gen. Tech. Rep. NE-221. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 80.
- Carpenter, Constance A.; Smith, Marie-Louise; Fay, Stephen. 1995. What do ecological unit boundaries mean? The dual role of ecological units in ecosystem analysis: examples from the New England and New York state. In: Thompson, Joyce Elma, comp. Analysis in support of ecosystem management. Analysis workshop III; 1995 April 10-13; Fort Collins, CO. Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Analysis Center: 8-19.
- D. H. DeHayes; G. R. Strimbeck; P. G. Schaberg; G. J. Hawley. 1996. Membrane calcium depletion: A mechanism for acid precipitation-induced reductions in cold tolerance of red spruce. In: T. H. H. Chen and P. H. Li, comp. Fifth International Plant Cold Hardiness Seminar; August 5-8, 1996; Corvallis, OR. Corvallis, OR: Oregon State University: 176.

- Decker, Kelly L.M.; Fisher, Michael J.; Boerner, Ralph E.J. 1996. Landscape scale and microbial ecology. II. Soil enzyme activity. Supplement to Bulletin of the Ecological Society of America. 77(3): 106. Abstract.
- Decker, Kelly L.M.; Fisher, Michael J.; Boerner, Ralph E.J. 1996. Landscape scale and microbial ecology. II. Soil enzyme activity. Ohio Journal of Science. 96(2): A-22. Abstract.
- Decker, Kelly L.M.; Morris, Sherri J.; Boerner, Ralph E.J. 1996. Ca:A1 ratio effects on competition between arbuscular mycorrhizal and ectomycorrhizal forest trees. In: 1st international conference on mycorrhizae; 1996 August 4-9; Berkeley, CA. [Place of publ. unknown]: [Publisher name unknown]. Poster Abstract.
- Dennis, Donald F.; Sendak, Paul E. 1996. Stumpage price trends in New England: 1964-1995. In: Brissette, John C., comp. 76th winter meeting of the New England Society of American Foresters; 1996 March 19-21; Lowell, MA. [Place of publ. unknown]: New England Society of American Foresters: 4. Poster Abstract.
- Falk, Laura; Lanier, John; Carpenter, Constance; Leak, William B.; Smith, Marie-Louise; Fay, Steve. 1996. Landscape of New Hampshire. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 383. Abstract.
- Frank, Robert M.; Stone, Timothy L.; Crawford, Hewlette S. 1996. Tree/wildlife diversity responses to silvicultural practices in northern conifers. In: Sustaining forests, sustaining people: proceedings of the 1995 SAF convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 413-414.
- Gove, J.H.; Houston, D.R. 1996. Monitoring the growth of American beech affected by beech bark disease in Maine using the Kalman filter. Environmental and Ecological Statistics. 3: 167-187.
- Gove, Jeffrey H.; Linder, Ernst; Tzilkowski, Walter M. 1995. Bimodality of the combined removal and signs-of-activities estimator for sampling closed animal populations. Environmental and Ecological Statistics. 3: 65-80.
- Gove, Jeffrey H.; Patil, Ganapati P.; Taillie, Charles. 1996. Diversity measurement and comparison with examples. In: Szaro, Robert C.; Johnson, David W., comps., eds. Biodiversity in managed landscapes: theory and practice. New York, NY: Oxford University Press: 157-175.
- Gregoire, Timothy G.; Valentine, Harry T. 1995. A sampling strategy to estimate the area and perimeter of irregularly shaped planar regions. Forest Science. 41 (3): 470-476.
- Hagan, John M.; VanderHaegen, W. Matthew; McKinley, Peter S. 1996. The early development of forest fragmentation effects on birds. Conservation Biology. 10 (1): 188-202.
- Harris, M.M.; Safford, L.O. 1996. Effects of season and four tree species on soluble carbon content in fresh and decomposing litter of temperate forests. Soil Science. 161 (2): 130-135.
- Hawley, G.J.; Schaberg, P.G.; DeHayes, D.H.; Strimbeck, G.R.; Cumming, J.R. 1996. Perturbations to membrane calcium: a mechanism for global change-induced cold injury. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 143. Abstract.
- Hollinger, D.Y.; Kelliher, F.M.; Schulze, E.-D.; Vygodskaya, N.N.; Varlagin, A.; Milukova, I. 1995. Initial assessment of multi-scale measures of CO<sub>2</sub> and H<sub>2</sub>O flux in the Siberian taiga. Journal of Biogeography. 22: 425-431.
- Horsley, S.B. 1996. Interaction of deer density and understory lighting with height of red maple (*Acer rubrum* L.) seedlings in Allegheny hardwood stands. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 48. Abstract.
- Horsley, Stephen B.; Ristau, Todd E. 1996. Pin Cherry effects on Allegheny hardwood stand development. I. Short-term impacts. In: Glenn, S., ed. Fifty years of progress: proceedings of the 50th annual meeting of the Northeastern Weed Science Society; 1996 January 2-5; Williamsburg, VA. [Place of publ. unknown]: Northeastern Weed Science Society: 49. Abstract.

Horsley, Stephen B.; Ristau, Todd E. 1996. Pin cherry influences development of Allegheny hardwood stands. Supplement to Bulletin of the Ecological Society of America. 77(3): 203. Abstract.

Iverson, Louis R., and Prasad, Anantha. 1996. Modeling present and potential future individual tree species importance values in the Eastern United States. In: Integration of cultural and natural ecosystems across landscapes: application of the science. 11th annual landscape ecology symposium. 1996 March 26-30; Galveston, TX. Abstract.

Iverson, Louis R.; Prasad, Anantha M.G.; Scott, Charles T. 1996. Preparation of forest inventory and analysis (FIA) and state soil geographic data base (STATSGO) data for global change research in the eastern United States. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 209-214.

Iverson, Louis R.; Scott, Charles T.; Dale, Martin E.; Parasad, Anantha. 1996. Development of an integrated moisture index for predicting species composition. In: Koehl, Michael; Gertner, George Z., eds. Caring for the forest: research in a changing world. Statistics, mathematics and computers. Proceedings of the meeting of IUFRO S4.11.00 XX World Congress; 1995 August 6-12; Tampere, Finland. Birmensdorf, Switzerland: Swiss Federal Institute for Forest, Snow and Landscape Research: 101-116.

Kenefic, Laura S.; Nyland, Ralph D. 1996. Structural development and consistency in uneven-aged northern hardwood stands. In: Sustaining forests, sustaining people: proceedings of the 1995 SAF convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 441-442.

Keys, James E., Jr.; Carpenter, Constance A.; Hooks, Susan L.; Koenig, Frank G.; McNab, Henry W.; Russell, Water E.; Smith, Marie-Louise. Supplement to Bulletin of the Ecological Society of America. 77(3): 232. Abstract.

Krusic, Rachel A.; Neefus, Chris D.; Yamasaki, Mariko; Pekins, Peter J. 1996. Echolocation calls of bats in the White Mountain National Forest: species identification using multivariate analysis. Bat Research News. 36(4): 81. Abstract.

Krusic, Rachel A.; Neefus, Chris D.; Yamasaki, Mariko; Pekins, Peter J. 1996. Habitat associations of bat species in the White Mountain National Forest. Bat Research News. 36(2-3): 27. Abstract.

Krusic, Rachel A.; Yamasaki, Mariko; Neefus, Christopher D.; Pekins, Peter J. 1996. Bat habitat use in White Mountain National Forest. Journal of Wildlife Management. 60 (3): 625-631.

Leak, William B. 1996. Long-term structural change in uneven-aged northern hardwoods. Forest Science. 42 (2): 160-165.

Leak, William B.; Smith, Marie-Louise. 1996. Sixty years of management and natural disturbance in a New England forested landscape. Forest Ecology and Management. 81: 63-73.

Long, R.P.; Horsley, S.B.; Lilja, P.R. 1996. Nutrient status and sugar maple health: liming effects on growth, vigor, seed crops, regeneration, and foliage chemistry in northcentral Pennsylvania. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 74. Abstract.

Luppold, William G.; Baumgras, John E. 1995. Price trends and relationships for red oak and yellow-poplar stumpage, sawlogs, and lumber in Ohio: 1975-1993. Northern Journal of Applied Forestry. 12 (4): 168-173.

Luppold, William G.; Baumgras, John E. 1995. Relationships among sawlog price trends, species & quality examined. National Hardwood Magazine. September: 37-38.

McGuinness, B.J.; Steiner, K.C. 1996. A heritage for the 21st century: Pennsylvania's native biological diversity conservation strategy. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 410-411.

- McGuinness, Barbara J. 1995. A heritage for the 21st century: summary and results of Pennsylvania's biodiversity conservation plan. In: Finley, James C.; Jones, Stephen B., eds. *Ecosystem management: translating concepts to practice*, 1995 Penn State School of Forest Resources issues conference; 1995 March 15-16; State College, PA. State College, PA: The Pennsylvania State University, School of Forest Resources: 51-57.
- McWilliams, William H.; Stout, Susan L.; Bowersox, Todd W.; McCormick, Larry H. 1995. Adequacy of advance tree-seedling regeneration in Pennsylvania's forests. *Northern Journal of Applied Forestry*. 12 (4): 187-191.
- McWilliams, William H.; White, Robert; Arner, Stanford L.; Nowak, Christopher A.; Stout, Susan L. 1996. Characteristics of declining forest stands on the Allegheny National Forest. Res. Note NE-360. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9.
- Miller, Gary W. 1996. Epicormic branching on Central Appalachian hardwoods 10 years after deferment cutting. Res. Pap. NE-702. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9.
- Miller, Gary W.; Wood, Petra Bohall; Nichols, Jeffrey V. 1996. Two-age silviculture—an innovative tool for enhancing species diversity and vertical structure in Appalachian hardwood. In: Eskew, Lane G., comp. *Forest health through silviculture. Proceedings of the 1995 national silviculture workshop*; 1995 May 8-11; Mescalero, NM. Gen. Tech. Rep. RM-GTR-267. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 175-182.
- Mitasova, Helena; Hofierka, Jaroslav; Zlocha, Maros; Iverson, Louis R. 1996. Modelling topographic potential for erosion and deposition using GIS. *International Journal of Geographical Information Systems*. 10 (5): 629-641.
- Morris, Sherri J.; Brinkman, Jennifer A.; Boerner, Ralph E.J. 1996. Landscape scale and microbial ecology. I. Nitrogen turnover. Supplement to Bulletin of the Ecological Society of America. 77(3): 314. Abstract.
- Morris, Sherri J.; Brinkman, Jennifer A.; Boerner, Ralph E.J. 1996. Landscape scale and microbial ecology. I. Nitrogen turnover. *Ohio Journal of Science*. 96(2): A-22. Abstract.
- Muzika, Rose-Marie; Hunsucker, Robert; DeMeo, Tom. 1996. Botanical reconnaissance of Big Run Bog Candidate Research Natural Area. Gen. Tech. Rep. GTR-NE-223. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 15.
- Neefus, Chris D.; Krusic, Rachel A. 1996. Computer-aided identification of bat species based on broadband detection of echolocation calls. *Bat Research News*. 36(4): 94. Abstract.
- Nowak, Christopher A. 1996. Wood volume increment in thinned, 50- to 55-year-old, mixed-species Allegheny hardwoods. *Canadian Journal of Forest Research*. 26: 819-835.
- Oswald, Brian P.; Zhang, Lianjun; Green, Thomas H.; Stout, Susan L. 1995. Height-diameter relationships of dominant trees in the mixed upland hardwood forests in north Alabama. In: Edwards, M. Boyd, comp. *Proceedings of the 8th biennial southern silvicultural research conference*; 1994 November 1-3; Auburn, AL. Gen. Tech. Rep. SRS-1. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 596-598.
- Pilgrim, Sid; Falk, Laura; Spurduto, Dan; Desmaris, Ken; Fay, Steve; Leak, William B.; Smith, Marie-Louise; Carpenter, Constance; Publicover, David. 1996. Land type associations of New Hampshire. In: Brissette, John C., comp. *76th winter meeting of the New England Society of American Foresters*; 1996 March 19-21; Lowell, MA. [Place of publ. unknown]: New England Society of American Foresters: 19. Poster Abstract.
- Pilgrim, Sid; Falk, Laura; Spurduto, Dan; Desmaris, Ken; Leak, William B.; Smith, Marie-Louise. 1996. Landtype associations of New Hampshire. In: *Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention*; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 378-379.

- Rice, Wanda B.; Howard, Theodore; Congalton, Russel; Rubin, Fay. 1996. Identifying shorefront lands with high land use conversion potential in northern New Hampshire using a geographic information system. In: Brissette, John C., comp. 76th winter meeting of the New England Society of American Foresters; 1996 March 19-21; Lowell, MA. [Place of publ. unknown]: New England Society of American Foresters: 20-21. Poster Abstract.
- Ristau, Todd E.; Horsley, Stephen B. 1996. Pin cherry effects on Allegheny hardwood stand development. II. Long-term impacts. In: Glenn, S., ed. Fifty years of progress: proceedings of the 50th annual meeting of the Northeastern Weed Science Society; 1996 January 2-5; Williamsburg, VA. [Place of publ. unknown]: Northeastern Weed Science Society: 49. Abstract.
- Ristau, Todd E.; Horsley, Stephen B.; McCormick, Larry H. 1996. Seasonal variations on non-aborescent vascular species diversity in Allegheny hardwoods. Supplement to Bulletin of the Ecological Society of America. 77(3): 376. Abstract.
- Royte, Joshua L.; Sperduto, Daniel D.; Lortie, John P. 1996. Botanical reconnaissance of Nancy Brook Research Natural Area. Gen. Tech. Rep. NE-216. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 23.
- Sandak, Paul E.; Koelling, Melvin R. 1996. Economics of maple syrup production. In: North American Maple Syrup Producers Manual. Ohio State University Extension Bulletin 856. Columbus, Ohio: Ohio State University: 144-154.
- Sasse, David B.; Pekins, Pete J. 1996. Summer roosting ecology of cavity-dwelling bats in the White Mountain National Forest. Bat Research News. 36(2-3): 31. Abstract.
- Schaberg, P.G.; Shane, J.B.; Cali, P.F. 1996. Genetic variation in field photosynthesis and photosynthetic capacity of Vermont red spruce during the cold season. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 35. Abstract.
- Schaberg, P.G.; Shane, J.B.; Hawley, G.J.; Strimbeck, G.R.; DeHayes, D.H.; Cali, P.F.; Donnelly, J.R. 1996. Thaw-induced changes in photosynthesis and cold hardiness of red spruce during winter. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 163. Abstract.
- Schaberg, P.G. 1996. Cold-season photosynthesis of red spruce in Vermont. Burlington, VT: University of Vermont. 117. Ph.D. dissertation.
- Schaberg, P.G.; Shane, J.B.; Hawley, G.J.; Strimbeck, G.R.; DeHayes, D.H.; Cali, P.F. 1996. Physiological changes in red spruce seedlings during a simulated winter thaw. Tree Physiology. 16 (6): 567-574.
- Schuler, Thomas M.; Miller, Gary W. 1996. Guidelines for using tree shelters to regenerate northern red oak. In: Brissette, John C., ed. Proceedings of the tree shelter conference; 1995 June 20-22; Harrisburg, PA. Gen. Tech. Rep. NE-221. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 37-45.
- Schwartz, Mark W.; Iverson, Louis R.; and Prasad, Anantha. Projected tree distribution shifts under global climate change in the fragmented Ohio landscape. In: Ecologists/biologists as problem solvers: program and abstracts: part 2. 1996 annual combined meeting of the ESA: 1996 August 10-14; Providence, RI. Supplement to Bulletin of the Ecological Society of America. 77(3): 106. Abstract.
- Schwartz, Mark W. 1996. Assessing the ability of plants to respond to climatic change through distribution shifts. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 184-191.
- Selva, Steven B. 1996. Using lichens to assess ecological continuity in northeastern forests. In: Davis, Mary B., comp., ed. Eastern old-growth forests: prospects for rediscovery and recovery. Washington, DC: Island Press: 35-48.
- Sendak, P.E.; Frank, R.M.; Brissette, J.C. 1996. Financial analysis of northern conifer stands under various silvicultural treatments. In: Sustaining forests, sustaining people: proceedings of the 1995 SAF convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 368-369.

Sendak, Paul E. 1996. Role of economic incentives in conserving wildlife habitat. In: Kohn, Michael; Gertner, George Z., eds. *Caring for the forest: research in a changing world. Statistics, mathematics and computers. Proceedings of the meeting of IUFRO XX World Congress; 1995 August 6-12; Tampere, Finland. Birmensdorf, Switzerland: Swiss Federal Institute for Forest, Snow and Landscape Research: 82-83. Abstract.*

Smith, Marie-Louise; Carpenter, Constance. 1996. Application of the USDA Forest Service national hierarchical framework of ecological units at the sub-regional level: the New England-New York example. In: Sims, Richard A.; Corns, Ian G.W.; Klinka, Karel, comps., eds. *Global to local: ecological land classification. Dordrecht, The Netherlands: Kluwer Academic Publishers: 187-198.*

Solomon, Dale S.; Leak, William B. 1995. Evaluation of methodology for detecting/predicting migration of forest species. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 175-182.*

Sperry, J.S.; Saliendra, N.Z.; Pockman, W.T.; Cochard, H.; Cruiziat, P.; Davis, S.D. 1996. New evidence for large negative pressures and their measurement by the pressure chamber method. *Plant Cell Environment*. 19: 427-436.

Stanton, R.C.; Horn, D.J.; Purrington, F.F. 1996. Ground beetles (carabidae) diversity and abundance in mixed-oak forests in southern Ohio. In: *Meeting of north central branch of Entomological Society of America; 1996 March 24-27; Omaha, NE. [Place of publ. unknown]: [Publisher name unknown]: Poster Abstract.*

Stout, S.L.; Nowak, C.A.; Horsley, S.B.; Long, R.P.; White, R.; McWilliams, W. 1996. Forest health on Pennsylvania's Allegheny Plateau. In: *Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 435-436.*

Stout, S.L.; deCalesta, D.S.; DeMarco, L. 1996. Can silviculture change deer impact? In: *Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 437-438.*

Stout, Susan L. 1995. Overview of ecosystem management and its importance. In: Finley, James C.; Jones, Stephen B., eds. *Ecosystem management: translating concepts to practice, 1995 Penn State School of Forest Resources issues conference; 1995 March 15-16; State College, PA. State College, PA: The Pennsylvania State University, School of Forest Resources: 1-12.*

Stout, Susan L.; Lawrence, R. 1996. Deer in Allegheny Plateau forests: learning the lessons of scale. In: *Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 92-98.*

Stout, Susan L.; Nowak, Christopher A.; Redding, James A.; White, Robert; McWilliams, William. 1995. Allegheny National Forest health. In: Eskew, Lane G., comp. *Forest health through silviculture: proceedings of the 1995 national silviculture workshop; 1995 May 8-11; Mescalero, NM. Gen. Tech. Rep. RM-GTR-267. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 79-86.*

Strimbeck, G.R.; Schaberg, P.G.; DeHayes, D.H.; Shane, J.B.; Hawley, G.J. 1995. Midwinter dehardening of montane red spruce during a natural thaw. *Canadian Journal of Forest Research*. 25: 2040-2044.

Styer, Jean W.; Carson, C. Walter; Horsley, S. 1996. The impact of white-tailed deer on the seed banks of two second-growth forests in the Allegheny National Forest, Pennsylvania. *Supplement to Bulletin of the Ecological Society of America*. 77(3): 429. Abstract.

Sutherland, Elaine Kennedy; Grassino-Mayer, Henri; Woodhouse, Connie. 1996. The history of fire in a southwestern Virginia *Pinus pungens* stand. In: *Fire in ecosystem management: shifting the paradigm from suppression to prescription; 1996 May 7-10; Boise, ID. [Place of publ. unknown]: [Publisher name unknown]. Poster Abstract.*

Sutherland, Elaine Kennedy; Hale, Betsy J.; Hix, David M. 1996. Regeneration attributes of tree species in the central hardwoods type. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 215. Abstract.

Sutherland, Elaine Kennedy; Yaussy, Daniel A.; Boerner, Ralph E.J. 1996. Mortality patterns in oak forests along a climatic and acid deposition gradient. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. In: Proceedings, 1995 meetings of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 168. Abstract.

Tritton, Louise M.; Sendak, Paul E. 1995. Ecological aspects of forest management planning: a northern hardwood forest case study. *Northern Journal of Applied Forestry*. 12 (3): 121-126.

Tyree, M.T.; Cochard, H. 1996. Summer and winter embolism in oak: impact on water relations. *Annales Des Sciences Forestiere*. 53: 173-180.

Tyree, Melvin T.; Ewers, Frank W. 1996. Hydraulic architecture of woody tropical plants. In: Mulkey, Stephen S.; Chazdon, Robin L.; Smith, Alan P., comps., eds. *Tropical forest plant ecophysiology*. New York, NY: Chapman & Hall: 217-243.

Whitehead, D.; Hogan, K.P.; Rogers, G.N.D.; Byers, J.N.; Hunt, J.E.; McSeveny, T.M. 1995. Performance of large open-top chambers for long-term field investigations of tree response to elevated carbon dioxide concentration. *Journal of Biogeography*. 22: 307-313.

Yaussy, Daniel A.; Sutherland, Elaine Kennedy; Hale, Betsy J. 1996. Rule-based, individual-tree regeneration model for forest simulators. In: Skovsgaard, J.P.; Johannsen, V.K., eds. *Modelling regeneration success and early growth of forest stands: proceedings from the IUFRO conference; 1996 June 10-13; Copenhagen, Denmark*. Horsholm, Denmark: Danish Forest and Landscape Research Institute: 176-182.

Zahka, G.A.; Baggett, K.L.; Wong, B.L. 1995. Inoculum potential and other VAM fungi parameters in four sugar maple forests with different levels of stand dieback. *Forest Ecology and Management*. 75: 123-134.

Zhang, Lianjun; Oswald, Brian P.; Green, Thomas H.; Stout, Susan L. 1995. Relative density measurement and species composition in the mixed upland hardwood forests of north Alabama. In: Edwards, M. Boyd, comp. *Proceedings of the 8th biennial southern silvicultural research conference; 1994 November 1-3; Auburn, AL. Gen. Tech. Rep. SRS-1*. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 467-472.

## Forest Products and Harvesting Research

- Adams, Edward L. 1996. PC-SOLVE III user's manual: a procedural guide for computer-based sawmill analysis. Gen. Tech. Rep. NE-215. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 36.
- Anderson, R. Bruce; Patterson, David W. 1996. Getting it right with automated quality control. *Furniture Design & Manufacturing*. (2): 132-135.
- Araman, Philip A.; West, Cynthia D. 1996. Announcing...the Hardwood Utilization Consortium. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 47. Abstract.
- Gatchell, Charles J. 1996. Designing a fixed-blade gang rip saw arbor with a pencil. *Forest Products Journal*. 46 (6): 37-40.
- Gatchell, Charles J.; Wiedenbeck, Jan. 1995. Cross cutting step offers numerous advantages, research shows. *Modern Woodworking*. October: 7, 12.
- Gatchell, Charles J.; Wiedenbeck, Janice K.; Walker, Elizabeth S. 1996. The effects of crosscutting before gang-ripping on dimension part yields from No. 1 and No. 2A Common red oak lumber. *Forest Products Journal*. 46 (2): 61-66.
- Huyler, Neil K.; LeDoux, Chris B. 1996. Cut-to-length harvesting on a small woodlot in New England: a case study. In: Blinn, Charles R. and Thompson, Michael A., eds. Planning and implementing forest operations to achieve sustainable forests: proceedings of joint meeting of Council on Forest Engineering and IUFRO; 1996 July 29-August 1; Marquette, MI. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station.
- Kline, D. Earl; Widoyoko, Agus; Wiedenbeck, Janice K.; Araman, Philip A. 1996. Yield-based performance evaluation of a rough-mill scanning-optimization system. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 27. Abstract.
- Kline, Earl D. 1995. Solving real manufacturing problems with computer simulation. *Modern Woodworking*. November: 16, 38.
- Lawson, Penny S.; Thomas, R. Edward; Walker, Elizabeth S. 1996. OPTIGRAMI V2 user's guide. Gen. Tech. Rep. NE-222. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 46.
- LeDoux, Chris B.; Gopalakrishnan, B.; Mudiyanur, Sheshadri. 1996. Maximizing financial yields while meeting landowner objectives and ecosystem goals. In: Blinn, Charles R. and Thompson, Michael A., eds. Planning and implementing forest operations to achieve sustainable forests: proceedings of joint meeting of Council on Forest Engineering and IUFRO; 1996 July 29-August 1; Marquette, MI. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station.
- Patterson, David W.; XIE, Sialoin (Sylvia). 1996. Structural beams from small-diameter Appalachian hardwood logs turned inside out. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 53. Abstract.
- Patterson, David W.; Anderson, R. Bruce. 1996. Use of statistical process control in the furniture and cabinet industries. *Forest Products Journal*. 46 (1): 36-38.
- Shupe, Todd F.; Choong, Elvin T.; Stokke, Douglas D.; Gibson, Mark D. 1996. Variation in cell dimensions and fibril angle for two fertilized even-aged loblolly pine plantations. *Wood and Fiber Science*. 28 (2): 268-275.
- Stewart, John; Lemaster, Richard. 1995. NC State program offers new advances in tooling. *Modern Woodworking*. December: 1, 8-9.
- Thomas, Edward; Wiedenbeck, Jan; Hoff, Kris. 1996. Make informed decisions in the rough mill using new and improved computer simulation programs. In: Szymani, Ryszard, ed. Proceedings of CIFAC 1996 international symposium; 1996 May 7-8; High Point, NC. Berkeley, CA: Wood Machining Institute: 47-56.

Thomas, R. Edward. 1996. ROMI-RIP: an analysis tool for rip-first roughmill operations. *Forest Products Journal*. 46 (2): 57-60.

Widoyoko, Agus. 1996. Evaluation of color-based machine vision for lumber processing in furniture rough mills. Blacksburg, VA: Virginia Polytechnic Institute & State University. 88. M.S. thesis.

Wiedenbeck, Jan; Scheerer, Cathy. 1996. A report on rough mill yield practices and performance—how well are you doing? In: *Hardwood Symposium Proceedings*; 1996 May 8-11; Cashiers, NC. Memphis, TN: Hardwood Research Council:

Wiedenbeck, Jan; Scheerer, Cathy. 1996. Wood component makers commit to yield improvement. *Wood & Wood Products*. 101 (8): 206,208,211,372.

Wiedenbeck, Jan; Thomas, R. Ed. 1995. Increasing opportunities for yield improvement. *Modern Woodworking*. November: 21.

Wiedenbeck, Jan; Thomas, R. Ed. 1995. Rough mill study identifies yield improvement opportunities. *Millwork Manufacturing*. 12 (3): 22-23.

Wiedenbeck, Janice K.; Buehlmann, Urs. 1996. Character in furniture: using more of the wood resource. In: *Forest Products Society annual meeting: abstracts*; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 64. Abstract.

Forest Protection  
Research

Aber, John D.; Reich, Peter B.; Goulden, Michael L. 1996. Extrapolating leaf CO<sub>2</sub> exchange to the canopy: a generalized model of forest photosynthesis compared with measurements by eddy correlation. *Oecologia*. 106: 257-265.

Alexeyev, V.; Birdsey, R.; Stakanov, V.; Korotkov, I. 1995. Carbon in vegetation of Russian forests: methods to estimate storage and geographical distribution. *Water, Air and Soil Pollution*. 82: 271-282.

Baranchikov, Yuri; Vshivkova, Tamara; Montgomery, Michael. 1995. Suitability of foreign tree species for *Lymantria mathura* Moore. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213*. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 49. Abstract.

Baranchikov, Yuri N.; Nikitenko, Galina N.; Montgomery, Michael E. 1995. The Russian and Ukrainian literature on the gypsy moth. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213*. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 48. Abstract.

Barber, Klaus; Campbell, Joe; Crookston, Nick; Dahms, Cathy; Day, John; Mowerer, Todd. 1996. Mowerer, H.Todd, tech. comp. Decision support system for ecosystem management: an evaluation of existing systems. *Gen. Tech. Rep. RM*. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Barker, M.J.; Skilling, D.D.; Houston, D.R.; Ostry, M.E. 1995. Propagation of American beech with resistance to beech bark disease. *Phytopathology* 85(10): 1192. Abstract.

Bauer, Leah S.; Miller, Deborah L.; Onstad, David W.; Maddox, Joseph V.; McManus, Michael L. 1995. Studies on the transmission of an exotic microsporidium that infects the gypsy moth. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213*. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 50. Abstract.

Bell, J.C.; Grigal, D.F.; Bates, P.C.; Butler, C.A. 1996. Spatial patterns in carbon storage in a Lake States' landscape. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214*. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 198-202.

Birdsey, R.A.; Heath, L.S. 1995. Carbon changes in U.S. forests. In: Joyce, Linda S., ed. *Productivity of America's forests and climate change. Gen. Tech. Rep. RM-GTR-271*. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 56-70.

Birdsey, Richard A.; Hom, John L.; Emery, Marla. 1996. The Northern Global Change Research Program. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214*. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 1-6.

Bischoff, D.S.; Slavicek, J.M. 1996. Identification of a LdMNPV gene with homology to the viral enhancing factor gene of TnGV. In: 15th annual meeting of the American Society for Virology; 1996 July 13-17; London, ON. [Place of publ. unknown]: American Society for Virology: 114. Abstract.

Bischoff, David S.; Slavicek, James M. 1995. Identification of the *Lymantria dispar* nuclear polyhedrosis virus 25K gene. Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213*. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 55. Abstract.

Bischoff, David S.; Slavicek, James M. 1995. Sequence characterization and temporal expression of an early gene in the *Lymantria dispar* nuclear polyhedrosis virus. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 56. Abstract.

Bischoff, David S.; Slavicek, James M. 1995. Identification and characterization of an early gene in the *Lymantria dispar* multinucleocapsid nuclear polyhedrosis virus. *Journal of General Virology*. 76: 2933-2940.

Bloomfield, Janine; Vogt, Kristiina; Wargo, Philip M. 1996. Tree root turnover and senescence. In: Waisel, Yoav; Eshel, Amram; Kafafi, Uzi, comps., eds. *Plant roots. The hidden half*. New York, NY: Marcel Dekker: 363-381.

Bove, James R.; Burbank, Diane H.; Capen, David E.; Wade, Gary L. 1996. Comparing tree productivity and ground flora composition between two ecological classification systems on the Green Mountain National Forest, Vermont. Supplement to *Bulletin of the Ecological Society of America*. 77(3): 47. Abstract.

Butt, Tariq M.; Shields, Kathleen S. 1996. The structure and behavior of gypsy moth (*Lymantria dispar*) hemocytes. *Journal of Invertebrate Pathology*. 68: 1-14.

Carter, Jane L.; Peacock, John W.; Neale, Laura; Talley, Steve E. 1995. A field assessment of the effects of *Bacillus thuringiensis* on non-target Lepidoptera: light trap sampling. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency research forum 1995; 1995 January 17-20; Annapolis, MD*. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 59. Abstract.

Castello, John D.; Wargo, Philip M.; Jacobi, Volker; Bachand, George D.; Tobi, Donald R.; Rogers, Mary A.M. 1995. Tomato mosaic virus infection of red spruce on Whiteface Mountain, New York: prevalence and potential impact. *Canadian Journal of Forest Research*. 25: 1340-1345.

Christiansen, Tim A.; Perry, Sue A.; Perry, William B. 1996. Microhabitat effects of litter temperature and moisture on forest-floor invertebrate communities. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA*. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 153. Abstract.

Colbert, J.J. 1995. Introduction: models as links between empiricism and theory in insect ecology. *Computers and Electronics in Agriculture*. 13 (2): 87-90.

Colbert, J.J.; Xu, Rumei; Jiang, Nan-qing. 1995. A simplified gypsy moth system: model definition and description. *Computers and Electronics in Agriculture*. 13 (2): 115-131.

Coleman, M.D.; Dickson, R.E.; Isebrands, J.G. 1996. Root growth and respiration of aspen in response to ozone and elevated carbon dioxide. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA*. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 20. Abstract.

Coleman, M.D.; Dickson, R.E.; Isebrands, J.G.; Karnosky, D.F. 1995. Carbon allocation and partitioning in aspen clones varying in sensitivity to tropospheric ozone. *Tree Physiology*. 15: 593-604.

Coleman, M.D.; Dickson, R.E.; Isebrands, J.G.; Karnosky, D.F. 1996. Root growth and physiology of potted and field-grown trembling aspen exposed to tropospheric ozone. *Tree Physiology*. 16: 145-152.

Coleman, M.D.; Isebrands, J.G.; Dickson, R.E.; Karnosky, D.F. 1995. Photosynthetic productivity of aspen clones varying in sensitivity to tropospheric ozone. *Tree Physiology*. 15: 585-592.

D'Amico, Vincent; Elkinton, Joseph S.; Wood, H. Alan; Podgwaite, John D.; McManus, Michael L.; Slavicek, James; Burand, John P. 1995. A field test of genetically engineered gypsy moth NPV. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 61. Abstract.

D'Amico, Vincent; Elkinton, Joseph S.; Wood, H. Alan; Podgwaite, John D.; McManus, Michael L.; Slavicek, James; Burand, John P. 1995. A field test of genetically engineered gypsy moth NPV. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 61. Abstract.

D'Amico, Vincent; Elkinton, Joseph S. 1995. Rainfall effects on transmission of gypsy moth (Lepidoptera: Lymantriidae) nuclear polyhedrosis virus. *Environmental Entomology*. 24 (5): 1144-1149.

D'Amico, Vincent; Elkinton, Joseph S.; Dwyer, Greg; Burand, John P. 1996. Virus transmission in gypsy moths is not a simple mass action process. *Ecology*. 77 (1): 201-206.

David, Mark B.; Lawrence, Gregory B. 1996. Soil and soil solution chemistry under red spruce stands across the northeastern United States. *Soil Science*. 161 (5): 314-328.

DeBenedictis, John A.; Liebhold, Andrew M.; Powell, Jerry A. 1995. Studies of pheromone attraction and inheritance using virgin females of *Choristoneura* species, in the Central Sierra Nevada, California. In: Powell, Jerry A., ed. Biosystematic studies of conifer-feeding *Choristoneura* (Lepidoptera: Tortricidae) in the western United States. Vol. 115. Berkeley, CA: University of California Press: 153-165.

DeGaetano, Arthur T. 1996. Delineation of climate regions in the Northeastern United States. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 7. Abstract.

Dennis, Donald F. 1995. Assessing and incorporating extra market values in decisions concerning forest ecosystems. In: Sessions, John; Brodie, J. Douglas, eds. Management systems for a global economy with global resource concerns. Proceedings of the 1994 symposium on systems analysis in forest resources; 1994 September 6-9; Pacific Grove, CA. Bethesda, MD: Society of American Foresters: 161-166.

Dennis, Donald F. 1996. Review of "forest resources in Europe 1950-1990". *The Quarterly Review of Biology*.

Dickson, R.E.; Tomlinson, P.T. 1996. Oak growth, development and carbon metabolism in response to water stress. *Annals of Science and Forestry*. 53: 181-193.

Dix, Mary Ellen; Jennings, Daniel T. 1995. Predation by *Misumenop Asperatus* (Araneae, Thomisidae) on the metallic pitch nodule moth *Retinia Metallica* (Lepidoptera, Tortricidae). *Journal of Arachnology*. 23: 207-208.

Du, X.; Thiem, S.M. 1996. Characterization of host range factor 1 (hrf-1) expression in *Lymantria dispar* M nuclear polyhedrosis virus (MNPV) and recombinant autographa californica MNPV-infected LD652Y cells. In: 15th annual meeting of the American Society for Virology; 1996 July 13-17; London, ON. [Place of publ. unknown]: American Society for Virology: 153. Abstract.

Dubois, Normand R. 1993. Review of "Bacillus thuringiensis, an environmental biopesticide theory and practice." In: Entwistle Philip W.; Cory Jenny S.; Baily Mark J.; Higgs, Stephen; Wiley, John & Sons, eds. Entomological Society of America. Vol. 28 (I) March 1996. 20-21. Book Review.

Dubois, Normand R.; Keena, Melody A. 1995. Analysis of the effect of repeated treatments of *Bacillus thuringiensis* on gypsy moth populations. In: Program and abstracts: SIP 28th annual meeting; 1995 July 16-21; Ithaca, NY. Ithaca, NY: Cornell University: 16. Abstract.

Dubois, Normand R.; Keena, Melody A.; Huntley, Pamela; Newman, DeAdra. 1995. Effect of repeated treatments of *Bacillus thuringiensis* against gypsy moth populations: initial survey. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 64. Abstract.

Dubois, Normand R.; Dean, Donald H. 1995. Synergism between CryIA insecticidal crystal proteins and spores of *Bacillus thuringiensis*, other bacterial spores, and vegetative cells against *Lymantria dispar* (Lepidoptera: Lymantriidae) larvae. *Journal of Environmental Entomology*. 24 (6): 1741-1747.

Engstrom, Erik S.; Meegan, Sean K.; Perry, Sue A.; Perry, William B. 1996. Effects of acidic precipitation on leaf decomposition rates, microbial biomass, and leaf pack macroinvertebrates in six streams on the Allegheny Plateau of West Virginia. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 154-156.

Eshita, Steven M.; Koch, Jennifer L.; Kamalay, Joseph C. 1996. Pathogenesis-related proteins that show similarity to PR-10 proteins were induced in American elm xylem by infection with the Dutch elm disease fungus. In: 8th international congress on molecular plant-microbe interactions; 1996 July 14-19; Knoxville, TN. [Place of publ. unknown]: [Publisher name unknown]. Abstract.

Eshita, Steven M.; Roberto, Nick H.; Beale, John M.; Mamiya, Blain M.; Workman, Ryan F. 1995. Bacillomycin Lc, a new antibiotic of the iturin group: isolations, structures, and antifungal activities of the congeners. *Journal of Antibiotics*. 48 (11): 1240-1247.

Falchieri, David; Mierzejewski, Karl; Maczuga, Steven. 1995. Effects of droplet density and concentration on the efficacy of *Bacillus thuringiensis* and carbaryl against gypsy moth larvae (*Lymantria dispar* L.). *Journal of Environmental Science Health*. B30 (4): 535-548.

Fast, Jerome D.; Heilman, W.E. 1996. The effect of regional-scale soil-moisture deficits on mesoscale atmospheric dynamics that influence fire severity. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & aerobiology; 1996 January 28-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 280-283.

Fernandez, Ivan J.; Rustad, Lindsey E.; Simmons, Jeffrey A.; McLaughlin, James W. 1996. The Howland Integrated Forest Study (HIFS)-ecosystem research on atmospheric influences governing forest function. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 67. Abstract.

Fernandez, Ivan J.; Lawrence, Gregory B.; Son, Yowhan. 1995. Soil-solution chemistry in a low-elevation spruce-fir ecosystem, Howland, Maine. *Water, Air and Soil Pollution*. 84: 129-145.

Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. 1995. Proceedings, U.S. Department of Agriculture Interagency gypsy moth research forum. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 133.

Fredericksen, T.S.; Joyce, B.J.; Skelly, J.M.; Steiner, K.C.; Kolb, T.E.; Kousterick, K.B. 1995. Physiology, morphology, and ozone uptake of leaves of black cherry seedlings, saplings, and canopy trees. *Environmental Pollution*. 90: 1-11.

Fredericksen, T.S.; Kolb, T.E.; Skelly, J.M.; Steiner, K.C.; Joyce, B.M.; Savage, J.E. 1996. Light environment alters ozone uptake per net photosynthetic rate in black cherry trees. *Tree Physiology*. 16: 485-490.

Fredericksen, T.S.; Steiner, K.C.; Skelly, J.M.; Joyce, B.J.; Kolb, T.E.; Kousterick, K.B. 1996. Diel and seasonal patterns of leaf gas exchange and xylem water potential of different-sized *Prunus serotina* Ehrh. trees. *Forest Science*. 42 (3): 1-7.

Fredericksen, Todd S.; Skelly, John M.; Steiner, Kim C.; Kolb, Thomas E. 1996. Ozone exposure, uptake, and response of different-sized black cherry trees. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 38-40.

Frey, Serita D. 1996. Workshop on effects of management on forest soil; a report. Gen. Tech. Rep. NE-217. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 13.

Friedland, Andrew J.; Miller, Eric K. 1996. Elemental cycling response of an Adirondack subalpine spruce-fir forest to atmospheric and environmental change. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 77-81.

Garner, K.J.; Slavicek, J.M. 1996. Identification and characterization of a RAPD-PCR marker for distinguishing Asian and North American gypsy moths. *Insect Molecular Biology*. 5 (2): 81-91.

Garner, Karen; Schreiber, David; Slavicek, James. 1995. Status of nuclear DNA markers. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. In: Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. 213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 69. Abstract.

Gawel, James E.; Ahner, Beth A.; Friedland, Andrew J.; Morel, Francois M.M. 1996. Role for heavy metals in forest decline indicated by phytochelatin measurements. *Nature*. 381: 64-65.

Ghent, John H.; Thomas, Susan J.; Twardus, Daniel B.; Gottschalk, Kurt W.; Teske, Milton E. 1996. A demonstration of gypses: the gypsy moth decision support system. Tech. Pap. 961036. St. Joseph, MI: American Society of Agricultural Engineers. 6.

Glass, R.J.; More, T.A.; Echelberger, H.E. 1996. Incorporating broad-based public values into natural resource decisionmaking. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 321-327.

Goltz, S.M. 1996. Temporal and spatial trends of fluxes and concentrations of CO<sub>2</sub> above and within the canopy at Howland, Maine: preliminary results. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 229. Abstract.

Goltz, S.M.; Smith, James A. 1996. An energy balance model for forest canopies: a case study. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 228. Abstract.

Gottschalk, Kurt W. 1995. Using silviculture to improve health in northeastern conifer and eastern hardwood forests. In: Eskew, Lane G., comp. Forest health through silviculture. Proceedings of the 1995 national silviculture workshop; 1995 May 8-11; Mescalero, NM. Gen. Tech. Rep. RM-GTR 267. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 219-226.

Gray, David R.; Ravlin, F. William. 1995. Geographic robustness of a three-phase model of gypsy moth egg phenology. In: Fosbroke, Sandra, L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 70. Abstract.

Greenwood, Michael S.; Hutchinson, Keith W. 1996. Genetic aftereffects of increased temperature in *Larix*. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 56-62.

- Griffith, Michael B.; Perry, Sue A.; Perry, William B. 1995. Leaf litter processing and exoenzyme production on leaves in streams of different pH. *Oecologia*. 102: 460-466.
- Harney, S.K.; Wentworth, T.S. Wargo, P.M. 1995. *Phialocephala fortinii*, a potential fine root pathogen, isolated from red spruce. *Phytopathology* 85(10): 1141. Abstract.
- Hastings, F.L.; Hain, F.P.; Smith, H.R.; ODell, T.M. 1995. Natural enemies of the gypsy moth at the leading edge of its invasion into the southern U.S. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 76. Abstract.
- Hastings, F.L.; Hain, F.P.; Smith, H.R.; ODell, T.M.; Cook, S.P. 1995. Natural enemies of the gypsy moth at the leading edge of the invasion into the southern U.S. In: Hain, Fred P.; Salom, Scott M.; Ravlin, William F.; Payne, Thomas L.; Raffa, Kenneth F., eds. Behavior, population dynamics and control of forest insects. Proceedings of the IUFRO joint conference; 1994 February 6-11; Maui, HI. Wooster, OH: The Ohio State University, Ohio Agricultural Research and Development Center:
- Hawley, G.J.; DeHayes, D.H. 1996. Impact of natural thinning on the genetic diversity of *Pinus banksiana* populations. In: Forest management impacts on ecosystem processes: 14th North American forest biology workshop; 1996 June 16-20; Quebec City, PQ. Quebec City, PQ: Universite Laval: 86. Abstract.
- Heagle, Allen S.; Miller, Joseph E.; Chevone, Boris I.; Dreschel, Thomas W.; Manning, William J.; McCool, Patrick M. 1995. Response of a white clover indicator system to tropospheric ozone at eight locations in the United States. *Water, Air and Soil Pollution*. 85: 1373-1378.
- Heath, Linda S.; Birdsey, Richard A. 1996. Carbon sequestration on nonindustrial private forestlands in the US. In: Baughman, Melvin, J., ed. Proceedings of symposium on nonindustrial private forests: learning from the past, prospects for the future; 1996 February 18-20; Washington, DC. St. Paul, MN: University of Minnesota, Minnesota Extension Service: 326-333.
- Heath, Linda S.; Birdsey, Richard A.; Row, Clark; Plantinga, Andrew J. 1996. Carbon pools and fluxes in U.S. forest products. In: Apps, Michael J.; Price, David T., comps., eds. Forest ecosystems, forest management and the global carbon cycle. Berlin, Germany: Springer-Verlag: 271-278.
- Heilman, Warren E. 1996. Overview of current research on atmospheric interactions with wildland fires. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 192-195.
- Heilman, Warren E.; Zasada, John C.; Teclaw, Ronald M.; Buckley, David S. 1996. Harvesting effects on the microclimate of northern hardwood forests in the upper Great Lakes region. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & Aerobiology; 1996 January 28-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 397-400.
- Hendrick, R.L.; Pregitzer, K.S. 1993. The dynamics of fine root length, biomass and nitrogen content in two northern hardwood ecosystems. *Canadian Journal of Forest Research*. 23 (12): 2507-2520.
- Hendrick, Ronald L.; Pregitzer, Kurt S. 1996. Temporal and depth-related patterns of fine root dynamics in northern hardwood forests. *Journal of Ecology*. 84: 167-176.
- Hendrix, D.L.; Perkins, H.H., Jr.; Valaitis, A. 1995. Chemical characterization of cotton insect honeydew and elimination of stickiness of honeydew-contaminated lint. In: Constable, G.A., Forrester, N.W., eds. Challenging the future: proceedings of the world cotton research conference; 1994 February 14-17; Brisbane, Australia. East Melbourne, Australia: CSIRO Australia: 437-441.

Hermes, Daniel A.; Mattson, William J.; Karowe, David N.; Coleman, Mark D.; Trier, Terry M.; Birr, Bruce A. 1996. Variable performance of outbreak defoliators on aspen clones exposed to elevated CO<sub>2</sub> and O<sub>3</sub>. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program*; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 43-55.

Hiremath, Shivanand T.; Lehtoma, Kirsten; Prasad, Roopa. 1995. Complete nucleotide sequencing of a clone encoding the large subunit of vitellogenin from the gypsy moth. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995*; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 78. Abstract.

Hislop, J.E.; Hallet, R.A.; Hornbeck, J.W. 1995. Microwave digestion of forest soil and plant tissue samples. In: *Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention*; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 396-397.

Hoch, Gernot; Zubrik, Milan. 1995. The parasitoid complex of the gypsy moth in high and low level populations in eastern Austria and Slovakia. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995*; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 79. Abstract.

Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. 1996. *Proceedings, 1995 meeting of the Northern Global Change Program*. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 238.

Hom, John L.; Krywult, Marek; Bytncrowicz, Andrzej; Pearcy, Kevin E. 1996. Internal uptake and assimilation of gaseous nitric acid by western forest tree species. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program*; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 82. Abstract.

Host, George E.; Theseira, Gary W.; Isebrands, J.G. 1996. Modeling impacts of CO<sub>2</sub> ozone, and climate change on tree growth. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program*; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 33-37.

Houston, David R. 1995. Effects of paraformaldehyde on sugar maples tapped for sap. II. Temporal development of discoloration and decay. *Phytopathology* 85(12): 1557. Abstract.

Huyler, Neil K.; LeDoux, Chris B. 1996. Cut-to-length harvesting on a small woodlot in New England: a case study. In: Blinn, Charles R.; Thompson, Michael A., eds. *Planning and implementing forest operations to achieve sustainable forests: Proceedings of papers presented at the joint meeting of the Council on Forest Engineering and IUFRO*; 1996 July 29-August 1; Marquette, MI. Gen. Tech. Rep. NC-186. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 102-108.

Isebrands, J.G.; Karnosky, D.F. 1996. Interacting effects of ozone and CO<sub>2</sub> on growth and physiological process in northern forest trees. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program*; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 22. Abstract.

Jiang, Nan-qing; Xu, Rumei; Colbert, J.J. 1995. A simplified gypsy moth model system: global behavior and parameter analysis. *Computers and Electronics in Agriculture*. 13 (2): 133-153.

Johnson, A.H.; Strimbeck, G.R. 1996. Thirty-three year changes in above- and below-ground biomass in northern hardwood stands in Vermont. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program*; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 169-174.

Jones, Elizabeth A.; Reed, David D.; Desanker, Paul V. 1994. Ecological implications of projected climate change scenarios in forest ecosystems of central North America. *Agricultural and Forest Meteorology*. 72: 31-46.

Joyce, B.J.; Steiner, K.C.; Skelly, J.M. 1996. Water use in forest canopy black cherry trees and its relationship to leaf gas exchange and environment. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program*; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 41. Abstract.

Joyce, Linda A.; Mills, John R.; Heath, Linda S.; McGuire, A.D.; Haynes, Richard W.; Birdsey, Richard A. 1995. Forest sector impacts from changes in forest productivity under climate change. *Journal of Biogeography*. 22: 703-713.

Juzwik, J.; Rugg, D.J.; Menes, P.J.; Cease, K.R. 1995. Soil water management and *Fusarium* root rot in eastern white pine seedlings. In: 1995 annual international research conference on methyl alternatives and emissions reduction; 1995 November 6-8; San Diego, CA. [Place of publ. unknown]: [Publisher name unknown]: 76-1. Abstract.

Juzwik, Jennifer; Menes, Peter J.; Rygg, David J. 1993. Soil moisture and *Fusarium* root rot of white pine seedlings. In: *Proceeding of Northeastern and Intermountain Forest and Conservation Nursery Associations*; 1993 August 2-5, 1993; St. Louis, MO. Gen. Tech. Rep. RM-243. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 85-90.

Kamalay, J.C.; Carey, D.W. 1995. Application of RAPD-PCR markers for identification and genetic analysis of American elm (*Ulmus americana* L.) selections. In: *Arboricultural Abstracts: International Society for Arboriculture*; Savoy, IL: Section 5: No. 14. 1996 April 1. Abstract.

Kamalay, Joseph C.; Carey, David W. 1996. Using DNA markers to identify American elm. *American Nurseryman*. (April 15): 56-57. Abstract.

Kamalay, Joseph C.; Carey, David W. 1995. Application of RAPD-PCR markers for identification and genetic analysis of American elm (*Ulmus americana* L.) selections. *Journal of Environmental Horticulture*. 13 (4): 155-159.

Karnosky, D.F.; Gagnon, Z.; Dickson, R.E.; Pechter, P.; Coleman, M.; Kull, Olevi; Sober, Anu; Isebrands, J.G. 1996. Effects of ozone and CO<sub>2</sub> on the growth and physiology of aspen. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program*; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 21. Abstract.

Karnosky, D.F.; Gagnon, Z.E.; Dickson, R.E.; Coleman, M.D.; Lee, E.H.; Isebrands, J.G. 1996. Changes in growth, leaf abscission, and biomass associated with seasonal tropospheric ozone exposures of *Populus tremuloides* clones and seedlings. *Canadian Journal of Forest Research*. 26: 23-37.

Kaufman, Michael G.; Strand, R. Malcolm; Kubiske, Mark E.; Mattson, William J.; Herms, Daniel A.; Walker, Edward D. 1996. Effects of elevated CO<sub>2</sub> and shade on the decomposition of senesced tree foliage: impacts on microbial activity. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program*; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 89-100.

Keena, Melody A.; Grinberg, Phyllis S.; Wallner, William E. 1995. Asian gypsy moth genetics: biological consequences of hybridization. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995*; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 80. Abstract.

Keena, Melody A. 1996. Comparison of hatch *Lymantria dispar* (Lepidoptera: Lymantriidae) eggs from Russia and the United States after exposure to different temperatures and durations of low temperature. *Annals of the Entomological Society of America*. 89 (4): 564-572.

- Keena, Melody A.; ODell, Thomas M.; Tanner, John A. 1995. Effects of diet ingredient source and preparation method on larval development of laboratory-reared gypsy moth (Lepidoptera: Lymantriidae). *Annals of the Entomological Society of America*. 88 (5): 672-679.
- Keena, Melody A.; ODell, Thomas M.; Tanner, John A. 1995. Phenotypic response of two successive gypsy moth (Lepidoptera: Lymantriidae) generations to environment and diet in the laboratory. *Annals of the Entomological Society of America*. 88 (5): 680-689.
- Kenefic, Laura S. Wolslegel. 1995. Quantitative assessment of wildlife habitat in uneven-aged northern hardwood stands. Syracuse, NY: State University of New York. 202. M.S. thesis.
- Kirschbaum, M.U.F.; Fischlin, A.; Cannell, M.G.R.; Cruz, P.; Galinski, W.; Neilson, R.P. 1996. Climate change impacts on forests. In: Watson, R.T.; Zinyowera, M.C.; Moss, R.H., comps., eds. *Climate change 1995. Impacts, adaptations and mitigation of climate change: scientific-technical analyses*. Cambridge, UK: Cambridge University Press: 97-122.
- Kittle, T.G.F.; Rosenbloom, N.A.; Painter, T.H.; Schimel, D.S.; Melillo, J.M.; Neilson, R.P. 1995. The VEMAP integrated database for modeling United States ecosystem/vegetation sensitivity to climate change. *Journal of Biogeography*. 22: 857-862.
- Kull, O.; Sober, A.; Coleman, M.D.; Dickson, R.E.; Isebrands, J.G.; Gagnon, Z. 1996. Photosynthetic responses of aspen clones to simultaneous exposures of ozone and CO<sub>2</sub>. *Canadian Journal of Forest Research*. 26: 639-649.
- Lane, C.J.; Reed, D.D.; Mroz, G.D.; Liechty, H.O. 1996. Width of sugar maple (*Acer saccharum*, Marsh) tree rings as affected by climate. *Canadian Journal of Forest Research*. 23: 2370-2375.
- Lawrence, Gregory B.; David, Mark B. 1996. Chemical evaluation of soil-solution in acid forest soils. *Soil Science*. 161 (5): 298-313.
- Lawrence, Gregory B.; David, Mark B.; Shortle, Walter C. 1995. A new mechanism for calcium loss in forest-floor soils. *Nature*. 378: 162-165.
- Lawrence, Gregory B.; David, Mark B.; Shortle, Walter C. 1996. Aluminum mobilization and calcium depletion in the forest floor of red spruce. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA*. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 112-117.
- LeBlanc, David; Haack, Robert. 1996. Growth responses of white oak and black oak to drought stress across gradients of acid deposition and microclimate. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. *Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA*. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 183. Abstract.
- Lee, Mi Kyong; Curtiss, A.; Dubois, N.R.; Dean, D.H. 1995. Mixing experiments between CRYIAA and CRYIAC insecticidal crystal proteins suggest oligomerization of toxins. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. *Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD*. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 81. Abstract.
- Liebholt, Andrew; Zhou, Guofa; Gribko, Linda; Hohn, Michael. 1994. Models that predict the spatial dynamics of gypsy moth *Lymantria Dispar* (L.) populations. In: Hain, Fred P.; Salom, Scott M.; Ravlin, William F.; Payne, Thomas L.; Raffa, Kenneth F., eds. *Behavior, population dynamics and control of forest insects. Proceedings of the IUFRO joint conference; 1994 February 6-11; Maui, HI*. Wooster, OH: The Ohio State University, Ohio Agricultural Research and Development Center: 491-498.
- Liebholt, Andrew M.; Gottschalk, Kurt W.; Muzika, Rose-Marie; Montgomery, Michael E.; Young, Regis; O'Day, Kathleen. 1996. Suitability of North American tree species to the gypsy moth: summary of field and laboratory tests. Gen. Tech. Rep. NE-211. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 34.
- Liechty, Hal O.; Kuuseoks, Eimar; Mroz, Glenn D. 1995. Dissolved organic carbon in northern hardwood stands with differing acidic inputs and temperature regimes. *Journal of Environmental Quality*. 24: 927-933.

- Lynch, James A.; Grimm, Jeffrey, W.; Corbett, Edward S. 1996. Enhancement of regional wet deposition estimates based on modeled precipitation inputs. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 8. Abstract.
- Lyon, S.M.; Montgomery, M.E. 1995. *Scymnus* (Pullus) *suturalis* Thunberg (Coleoptera: Coccinellidae): new locality records, and a report of feeding on hemlock woolly adelgid, *Adelges tsugae* Annand (Homoptera: Adelgidae). *Coleopterists Bulletin*. 49 (2): 118.
- MacDonald, N.W.; Burton, A.J.; Witter, J.A.; Richter, D.D. 1994. Sulfate absorption in forest soils of the Great Lakes region. *Soil Science Society of America Journal*. 58 (5): 1546-1555.
- MacDonald, N.W.; Zak, D.R.; Pregitzer, K.S. 1995. Temperature effects on kinetics of microbial respiration and net nitrogen and sulfur mineralization. *Soil Science Society of America Journal*. 59: 233-240.
- Maczuga, Steve; Mierzejewski, Karl. 1995. A computer program to predict gypsy moth larval mortality in sprayed forests. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 88. Abstract.
- Maczuga, Steven A.; Mierzejewski, Karl J. 1995. Droplet size and density effects of *Bacillus thuringiensis kurstaki* on gypsy moth (Lepidoptera: Lymantriidae) larvae. *Journal of Economic Entomology*. 88 (5): 1376-1379.
- McHale, P.J.; Mitchell, M.J. 1996. Disturbance effects on soil solution chemistry due to heating cable installation. *Biology and Fertility of Soils*. 22: 40-44.
- McHale, Patrick J.; Mitchell, Myron J.; Raynal, Dudley J.; Bowles, Francis P. 1996. Increasing soil temperature in a northern hardwood forest: effects on elemental dynamics and primary productivity. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 146-152.
- McLaughlin, J.W.; Reed, D.D.; Bagley, S.T.; Jurgensen, M.F.; Mroz, G.D. 1994. Foliar amino acid accumulation as an indicator of ecosystem stress for first-year sugar maple seedlings. *Journal of Environmental Quality*. 23 (1): 154-161.
- McLaughlin, James W.; Fernandez, Ivan J.; Goltz, Stewart M.; Rustad, Lindsey E.; Zibilske, Larry. 1996. Biogeochemical cycling of carbon, nitrogen, and sulfur at the Howland Integrated Forest study site, Howland, Maine. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 68-76.
- McLaughlin, James W.; Fernandez, Ivan J.; Richards, Karen J. 1996. Atmospheric deposition to low-elevation spruce-fir forest, Maine, USA. *Journal of Environmental Quality*. 25 (2): 248-259.
- McManus, Michael; Maddox, Joseph; Solter, Leellen; Jeffords, Michael. 1995. Distribution of microsporidia isolated from gypsy moth populations in Europe. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 94. Abstract.
- McManus, Michael L.; Leuschner, William A. 1995. An economic rationale for slowing the rate of spread of the gypsy moth in the United States. In: Hain, Fred P.; Salom, Scott M.; Ravlin, William F.; Payne, Thomas L.; Raffa, Kenneth F., eds. Behavior, population dynamics and control of forest insects. Proceedings of the IUFRO joint conference; 1994 February 6-11; Maui, HI. Wooster, OH: The Ohio State University, Ohio Agricultural Research and Development Center: 499-513.

McQuattie, Carolyn; Martin, Kendall; Rygiewica, Paul. 1996. Effects of elevated carbon dioxide and temperature on cytological changes in Douglas fir ectomycorrhizae. In: Szaro, Timothy M.; Bruns, Thomas D., comps., eds. Program and abstracts: First international conference on mycorrhizae; 1996 August 4-9; Berkeley, CA. [Place of publication unknown]: [Publisher name unknown]: 85. Poster Abstract.

McQuattie, Carolyn J. 1996. Cytological changes in needles of ectomycorrhizal and nonmycorrhizal pitch pine seedlings exposed to aluminum at two nutrient levels. *Ohio Journal of Science*. 96(2): A-27. Abstract.

McQuattie, Carolyn J.; Schier, George A. 1995. Effects of elevated carbon dioxide on the cytological responses of pitch pine mycorrhizae to aluminum at two nutrient levels. In: Topa, Mary A.; Rygiewicz, Paul T.; Cumming, Jonathan R., comps., eds. Dynamics of physiological processes in woody roots; 1995 October 8-11; Ithaca, NY. Ithaca, NY: Boyce Thompson Institute for Plant Research: 90. Poster Abstract.

Melillo, J.M.; Borchers, J.; Chaney, J.; Fisher, H.; Fox, S.; Neilson, R.P. 1995. Vegetation ecosystem modeling and analysis project (VEMAP): comparing biogeography and biogeochemistry models in a continental-scale study of terrestrial ecosystem responses to climate change and CO2 doubling. *Global Biogeochemical Cycles*. 9 (4): 407-437.

Miller, David R.; Reardon, Richard C.; McManus, Michael L. 1995. An atmospheric primer for aerial spraying of forests. FHM-NC-07-05. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area, State and Private Forestry. 17.

Miller, David R.; Wang, Yansen; Ducharme, Kirk M.; Yang, Xiusheng; Mierzejewski, Karl; McManus, Michael L. 1996. Some atmospheric turbulence and stability effects on aerial spray penetration into hardwood forest canopies. *Forest Science*. 42 (1): 93-101.

Miller, Eric K.; Friedland, Andrew J. 1994. Lead migration in forest soils: response to changing atmospheric inputs. *Environmental Science & Technology*. 28 (4): 662-669.

Minocha, Rakesh; Shortle, Walter C.; Coughlin, Jr., Daniel J.; Minocha, Subhash C. 1996. Effects of aluminum on growth, polyamine metabolism, and inorganic ions in suspension cultures of red spruce (*Picea rubens*). *Canadian Journal of Forest Research*. 26: 550-559.

Minocha, Rakesh; Shortle, Walter C.; Lawrence, Gregory B.; David, Mark B.; Minocha, Subhash C. 1996. Putrescine: a marker of stress in red spruce trees. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 119-130.

Montgomery, Michael E. 1996. Suitability of hosts for Asian and North American populations of the gypsy moth. In: Wilson, Jill; Schultz, Mark, comp. Proceedings, 4th international western forest insect and disease work conference; 1994 March 7-10; Albuquerque, NM. U.S. Department of Agriculture, Forest Service, Southwest Region, Forest Pest Management: 74.

Montgomery, Michael E.; Baranchikov, Yuri N. 1995. Comparison of performance on several tree species of gypsy moth from Central Asia, North America, and their hybrids. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 97. Abstract.

More, T.A.; Glass, R.J. 1996. Human values and their role in forest management. In: Sustaining forest, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 7-9.

More, Thomas A. 1995. Appendix B: Facts, values, and the human dimensions of global change. In: Emery, Marla; Paananen, Donna M. Humans, forests, and global environmental changes: planning a social science research agenda. Gen. Tech. Rep. NE-212. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 21-22.

More, Thomas A.; Dustin, Daniel L.; Knopf, Richard C. 1996. Behavioral consequences of campground user fees. *Journal of Park and Recreation Administration*. 14 (1): 81-93.

- Muzika, Rose-Marie; Gottschalk, Kurt W. 1995. Gypsy moth role in forest ecosystems: the good, the bad, and the indifferent. In: Eskew, Lane G., comp. Forest health through agriculture. Proceedings of the 1995 national silviculture workshop; 1995 May 8-11; Mescalero, NM. Gen. Tech. Rep. RM-GTR-267. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 99-104.
- Muzika, Rose-Marie; Hunsucker, Robert; DeMeo, Tom. 1996. Botanical reconnaissance of Big Run Bog candidate research natural area. Gen. Tech. Rep. NE-223. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 15.
- Nitao, James K.; Nair, Muraleedharan G.; Mattson, William J.; Herms, Daniel A.; Birr, Bruce A.; Coleman, Mark D.; Trier, Terry M.; Isebrands, J.G. 1996. Effects of elevated CO<sub>2</sub> and ozone on phenolic glycosides of trembling aspen. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 42. Abstract.
- Novotny, Julius. 1995. The use of Bt for Foray 48 FC (Novo Nordisk) for control of gypsy moth in the forests of the Slovak Republic. In: Fosbroke, Sandra, L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 101. Abstract.
- Novotny, Julius; Zubrik, Milan. 1995. Mortality agents affecting gypsy moth populations in Slovakia. In: Fosbroke, Sandra, L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 102. Abstract.
- ODell, Thomas M.; Mikus, David R.; Keena, Melody A.; Willis, Raymond B. 1995. Gypsy moth nutritional ecology: importance of iron bioavailability during various larval growth periods on the development and survival of their progeny. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 104. Abstract.
- Ocamb, Cynthia M.; Juzwik, Jennifer. 1995. Fusarium species associated with rhizosphere soil and diseased roots of eastern white pine seedlings and associated nursery soil. Canadian Journal of Plant Pathology. 17: 325-330.
- Ollinger, Scott V.; Aber, John D.; Reich, Peter B. 1996. Predicting the effects of tropospheric ozone on forest productivity in the northeastern U.S. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 217-224.
- Onstad, David W.; McManus, Michael L. 1996. Risks of host range expansion by parasites of insects. BioScience. 46 (6): 430-435.
- Palmer, James F.; Twery, Mark J. 1996. NED: a user controlled decision-support system for forest recreation environments. In: Thompson, Jerrilyn Lavarre; Lime, David W.; Gartner, Bill; Sames, Wayne M., comps. Proceedings of the 4th international outdoor recreation & tourism trends symposium and 1995 national recreation resource planning conference; 1995 May 14-17; St. Paul, MN. St. Paul, MN: University of Minnesota, College of Natural Resources and Minnesota Extension Service: 376-380.
- Pell, Eva J.; Brendley, Bryan W.; Sin, Judith P. 1996. Ozone-induced accelerated foliar senescence: implications for toxicity and compensation. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 13-19.
- Perala, Donald A.; Rollinger, Jeanette L. 1995. Comparison between soil and biomass carbon in adjacent hardwood and red pine forests. World Resource Review. 7 (2): 231-243.
- Plantinga, Andrew J.; Birdsey, Richard A. 1994. Optimal forest stand management when benefits are derived from carbon. Natural Resource Modeling. 8 (4): 373-387.

Podgwaite, J.D.; Reardon, R.C. 1995. Production and formulation of Gypchek. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 106. Abstract.

Potter, Brian E. 1996. Atmospheric mesoscale simulations of regional wildland fire episodes: looking for weather-related factors and scales of interaction. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program, 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 197. Abstract.

Pouyat, R.V.; Groffman, P.M.; Carreiro, M.M.; Bohlen, P.; Parmelee, R.W. 1996. Temperature and earthworm effects on C and N dynamics in oak stands along an urban-rural land use gradient. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program, 1995 March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 208. Abstract.

Pregitzer, Kurt S.; Reed, David D.; Mroz, Glenn D.; Burton, Andrew J.; Witter, John A.; Zak, Donald A. 1996. Climatic and pollution influences on ecosystem processes in northern hardwood forests. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 83-88.

Quinlan, Paul M. 1996. An assessment of wildlife habitat characteristics in Adirondack selection system stands. NY, NY: State University of New York. 110. M.S. thesis.

Rebeck, Joanne. 1996. The chronic response of yellow-poplar and eastern white pine to ozone and elevated carbon dioxide: three-year summary. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 23-30.

Reed, D.D.; Jones, E.A.; Densanker, P.V. 1994. Potential impact of projected climate change scenarios on individual tree species in central North America. In: Proceedings of the 13th international congress of biometeorology, part 2, volume 1; 1993 September 12-18; Calgary, AB. [Place of Publ. unknown]: [Publisher name unknown]: 910-919.

Reed, D.D.; Mroz, G.D.; Liechty, H.O.; Pregitzer, K.S.; Burton, A.J.; Zak, D.R. 1996. Studying the effects of air pollution on forests along exposure gradients: experience in the United States and opportunities for cooperation. In: Proceedings of the conference on climate and atmospheric deposition studies in forests; 1992 October 6-9; Nieborow, Poland. [Place of publ. unknown]: Polish Academy of Sciences: 109-115.

Reed, D.D.; Pregitzer, K.S.; Liechty, H.O.; Burton, A.J.; Mroz, G.D. 1994. Productivity and growth efficiency in sugar maple forests. *Forest Ecology and Management*. 70: 319-327.

Rickenbach, Mark G. 1996. Ecosystem management and NIPF landowners in Franklin County, Massachusetts: an assessment of attitudes. Amherst, MA: University of Massachusetts. 128. M.S. thesis.

Robert, Joy R.; Sharpe, William E. 1996. Long-term changes in the acidity of a DeKalb forest soil in the midregion of the Susquehanna River Watershed. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 131. Abstract.

Rollinger, Jeanette L.; Strong, Terry F. 1996. Carbon storage in managed forests of the northern Great Lakes states. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 203-207.

- Rowe, Jacquelyn M.; Perry, William B.; Perry, Sue A. 1996. Leaf litter processing in West Virginia mountain streams: effects of temperature and stream chemistry. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 157-160.
- Rustad, Lindsey E.; Fernandez, Ivan J.; Arnold, Stephanie. 1996. Experimental soil warming effect on C, N, and major element cycling in a low elevation spruce-fir forest soil. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 132-139.
- Schaefer, Paul E.; Shields, Kathleen S.; Aldrich, Jeffrey R. 1995. Larval gypsy moth dorsal abdominal glands: histology, ultrastructure and preliminary chemical identification of exudate. In: Fosbroke, Sandra L.C.; Gottschalk, K.W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 110-111. Abstract.
- Schier, George A.; McQuattie, Carolyn J. 1996. Effects of carbon dioxide enrichment on response of pitch pine grown at different nutrient levels to aluminum. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 31. Abstract.
- Schier, George A.; McQuattie, Carolyn J. 1995. Uptake and transport of nutrients in mycorrhizal and nonmycorrhizal pitch pine seedlings treated with aluminum. In: Topa, Mary A.; Rygielwicz, Paul T.; Cumming, Jonathan R., comps., eds. Dynamics of physiological processes in woody roots; 1995 October 8-11; Ithaca, NY. Ithaca, NY: Boyce Thompson Institute for Plant Research: 98. Poster Abstract.
- Schier, George A.; McQuattie, Carolyn J. 1996. Effects of carbon dioxide enrichment on response of pitch pine grown at different nutrient levels to aluminum. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 31. Abstract.
- Schreiber, Lawrence R.; Domir, Subhash C.; Gingas, V.M. 1996. Identification and control of bacterial contamination in callus cultures of *Ulmus americana*. *Journal of Environmental Horticulture*. 14 (2): 50-52.
- Schwartz, Mark W. 1996. Assessing the ability of plants to respond to climatic change through distribution shifts. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 184-191.
- Sharov, Alexei A.; Colbert, J.J. 1996. A model for testing hypotheses of gypsy moth, *Lymantria dispar* L., population dynamics. *Ecological Modelling*. 84: 31-51.
- Sharov, Alexei A.; Liebhold, Andrew M.; Ravlin, F. William. 1995. Prediction of gypsy moth (Lepidoptera: Lymantriidae) mating success from pheromone trap counts. *Environmental Entomology*. 24 (5): 1239-1244.
- Sharov, Alexei A.; Roberts, E. Anderson; Liebhold, Andrew M.; Ravlin, F. William. 1995. Gypsy moth (Lepidoptera: Lymantriidae) spread in the central Appalachians: three methods for species boundary estimation. *Environmental Entomology*. 24 (6): 1529-1538.
- Shields, Kathleen S.; Podgwaite, John D. 1995. Gypsy moth larval peritrophic membrane: surface structure and pathology. In: Greenplate, John, ed. Transitions: 1995 annual meeting of the Entomological Society of America; Lanham, MD. Lanham, MD: Entomological Society of America: 43. Abstract.

Shields, Kathleen S.; Podgwaite, John D. 1995. Peritrophic membrane: site of action for LdMNPV/optical brightener in gypsy moth larvae. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213: Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 112. Abstract.

Shortle, W.C.; Smith, K.T.; Dudzik, K.R.; Parker, S. 1995. Response of maple sapwood to injury and infection. *European Journal of Forest Pathology*. 25: 241-252.

Shortle, W.C.; Smith, K.T.; Minocha, R.; Alexeyev, V.A. 1995. Similar patterns of change in stemwood calcium concentration in red spruce and Siberian fir. *Journal of Biogeography*. 22: 467-473.

Shortle, Walter C.; Smith, Keven T.; Dudzik, Kenneth R. 1996. Decay diseases of stemwood: detection, diagnosis, and management. In: Raychaudhuri, S.P.; Maramorosch, K., comps., eds. *Forest trees and palms: diseases and control*. New Delhi and Calcutta, Oxford & IBM Publishing: 95-109.

Simmons, Jeffrey A.; Fernandez, Ivan J.; Briggs, Russell D. 1996. Soil respiration and net N mineralization along a climate gradient in Maine. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995, March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 140-145.

Slavicek, J.M.; Mercer, M.; Plazolles, N.H.; Kelly, M. 1996. Isolation of a LdMNPV polyhedron formation mutant that produces large numbers of occlusion deficient polyhedra. In: 15th annual meeting of the American Society for Virology; 1996 July 13-17; London, ON. [Place of publ. unknown]: American Society for Virology: 170. Abstract.

Slavicek, James M. 1995. Development of enhanced viral strains for cell culture production. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 113. Abstract.

Slavicek, James M. 1995. Development of improved *Lymantria dispar* nuclear polyhedrosis virus strains for virus production in cell culture systems. In: 1995 international chemical congress of Pacific Basin societies; 1995 December 17-22; Honolulu, HI. [Place of publ. unknown]: [Publisher name unknown]. Abstract.

Slavicek, James M.; Mercer, Melissa J., inventors. The United States of America as represented by the Secretary of Agriculture, assignee. Method of protecting plants from insects by applying gypsy moth virus with enhanced polyhedra production stability 1995. U.S. Patent 5,462,732. 1995 October 31. Int. C16 A01N 63/00; U.S. CL. 424/93.2.

Slavicek, James M.; Mercer, Melissa J.; Kelly, Mary Ellen; Hayes-Plazolles, Nancy. 1996. Isolation of a baculovirus variant that exhibits enhanced polyhedra production stability during serial passage in cell culture. *Journal of Invertebrate Pathology*. 67: 153-160.

Smith, K.T.; Shortle, W.C.; Ostrofsky, W.D. 1995. Aluminum and calcium in fine root tips of red spruce collected from the forest floor. *Canadian Journal of Forest Research*. 25: 1237-1242.

Smith, Kevin T. 1995. Trees at risk from good intentions. *Arborist News*. 4 (5): 27-29.

Smith, Kevin T.; Shortle, Walter C.; Minocha, Rakesh; Alexeyev, Vladislav A. 1996. Dynamics of calcium concentration in stemwood of red spruce and Siberian fir. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 230-238.

Solada, Steven W.; Perry, Sue A.; Perry, William B. 1996. Leaf litter decomposition and elemental change in three Appalachian mountain streams of different pH. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 161-164.

Solter, Leellen; McManus, Michael; Maddox, Joseph; Jeffords, Michael. 1995. Infectivity of non-indigenous gypsy moth microsporidia to native non-target forest Lepidoptera. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 92. Abstract.

Solter, Leellen F. 1995. Interaction of exotic microsporidia with forest Lepidoptera. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 114. Abstract.

Strand, R. Malcolm; Herms, Daniel A.; Kaufman, Michael G.; Kubiske, Mark E.; Mattson, William J.; Walker, Edward D. 1996. Effects of elevated CO<sub>2</sub> and shade on the decomposition of senesced tree foliage: impacts on the growth and survival of treehole mosquitoes. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 101-110.

Strimbeck, G.R.; Vann, David R.; Johnson, Arthur H. 1996. Effects of calcium fertilization and acid mist on calcium concentration and cold tolerance of red spruce needles. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 10-12.

Thiem, Suzanne M.; Du, Xianlin; Berner, Michelle; Quentin, Martha; Chilcote, Charley. 1995. Identification of a *Lymantria dispar* nuclear polyhedrosis virus host range gene. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 116. Abstract.

Thiem, Suzanne M.; Du, Xianlin; Quentin, Martha E.; Berner, Michelle M. 1996. Identification of a baculovirus gene that promotes *autographa californica* nuclear polyhedrosis virus replication in a nonpermissive insect cell line. *Journal of Virology*. 70 (4): 2221-2229.

Thompson, Ralph L.; Wade, Gary L.; Straw, R. Allen. 1996. Natural and planted flora of the log mountain surface-mined demonstration area, Bell County, Kentucky. In: Daniels, W. Lee; Burger, James A.; Zipper, Carl E., eds. Successes and failures: applying research results to insure reclamation success: proceedings of the 13th annual meeting of the American Society for Surface Mining and Reclamation; 1996 May 18-23; Knoxville, TN. Blacksburg, VA: Virginia Polytechnic Institute and State University, Research Division: 484-503.

Tomlinson, Patricia T.; Anderson, Paul D. 1996. Elevated CO<sub>2</sub> compensates for water stress in northern red oak. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 32. Abstract.

Twardus, Daniel B.; Ghent, John H.; Thomas, Susan J.; Gottschalk, Kurt W.; Teske, Milton E. 1996. An overview of gypses: the gypsy moth decision support system. Tech. Pap. 961035. St. Joseph, MI: American Society of Agricultural Engineers. 8.

Twery, Mark J. 1996. Innovative techniques for integrating objectives for ecosystem management: the Northeast Decision Model. In: Kohl, Michael; Gertner, George Z., eds. Caring for the forest: research in a changing world. Statistics, mathematics and computers. Proceedings of the meeting of IUFRO XX World Congress; 1995 August 6-12; Tampere, Finland. Birmensdorf, Switzerland: Swiss Federal Institute for Forest, Snow and Landscape Research: 183-188.

Valaitis, Algimantas P. 1995. *Bacillus thuringiensis* CryIA insecticidal toxins effect rapid release of gypsy moth midgut epithelium aminopeptidase. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 118. Abstract.

Valaitis, Algimantas P.; Lee, Mi Kyong; Rajamohan, Francis; Dean, Donald H. 1995. Identification of the *Bacillus thuringiensis* CryIAC toxin binding protein in the gypsy moth midgut. In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 119. Abstract.

Valaitis, Algimantas P.; Lee, Mi Kyong; Rajamohan, Francis; Dean, Donald H. 1995. Brush border membrane Aminopeptidase-N in the midgut of the gypsy moth serves as the receptor for the CryIA(c) delta-endotoxin of *bacillus thuringiensis*. *Insect Biochemistry and Molecular Biology*. 25 (10): 1143-1151.

Van Sambeek, J.W.; Preece, John E.; Navarerete, Nadia E.; Rink, George. 1996. Physiological and genotypic responses of central hardwood species to allelochemicals, other stresses, and their interactions. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-26; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 63-66.

Verry, Elon S. 1996. Methane evolution from Minnesota peatlands. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 165. Abstract.

Wagner, David L.; Henry Julie J.; Peacock, John W.; McManus, Michael L.; Reardon, Richard C. 1995. Common caterpillars of eastern deciduous forests. FHM-NC-04-95. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area, State and Private Forestry. 31.

Wallner, William E. 1995. Asian/Siberian/European gypsy moth research: are further efforts necessary? In: Fosbroke, Sandra L.C.; Gottschalk, Kurt W., eds. Proceedings, U.S. Department of Agriculture interagency gypsy moth research forum 1995; 1995 January 17-20; Annapolis, MD. Gen. Tech. Rep. NE-213. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 120. Abstract.

Wallner, William E. 1996. Biological pollutants and U.S. forests: whose problem—who pays? In: Proceedings, National Plant Board 69th annual meeting; 1995 August 13-16; San Diego, CA. [Place of publ. unknown]: California Department of Agriculture: 233-258.

Wallner, William E. 1996. Invasion of the tree snatchers. *American Nurseryman*. 183 (6): 28-30.

Wang, Yansen; Miller, David R.; Anderson, Dean E.; McManus, Michael L. 1995. A Lagrangian stochastic model for aerial spray transport above an oak forest. *Agricultural and Forest Meteorology*. 76: 277-291.

Wargo, P.M. 1996. Consequences of environmental stress on oak: predisposition to pathogens. *Annales des Sciences Forestieres*. 53: 359-368.

Wargo, Philip M. 1995. Disturbance in forest ecosystems caused by pathogens and insects. In: Eskew, Lane G., comp. Forest health through silviculture. Proceedings of the 1995 national silviculture workshop; 1995 May 8-11; Mescalero, NM. Gen. Tech. Rep. RM-GTR-267. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 20-25.

Webb, R.E.; Dill, N.H.; Podgwaite, J.D.; Shapiro, M.; Ridgway, J.L.; Vaughn, J.L. 1994. Control of third and fourth instar gypsy moth (Lepidoptera: Lymantriidae) with Gypchek combined with a stilbene disulfonic acid additive on individual shade trees. *Journal of Entomological Science*. 29 (1): 82-91.

- White, Christopher M.; Cobus, Mike; Manning, Robert E.; Seffel, Joel; More, Tom. 1996. Trends in the economics of sustainable outdoor recreation and tourism: the future of outdoor recreation fees for the public sector. In: Thompson, Jerrilyn Lavarre; Lime, David W.; Gartner, Bill; Sames, Wayne M., comps. Proceedings of the 4th international outdoor recreation & tourism trends symposium and 1995 national recreation resource planning conference; 1995 May 14-17; St. Paul, MN. St. Paul, MN: University of Minnesota, College of Natural Resources and Minnesota Extension Service: 185-293.
- White, Edwin H.; Buxbaum, Charles A.Z.; Nowak, Christopher A. 1996. Nutrient cycling in aggrading forests: 50 years of research at Pack Forest, New York. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program. 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 166. Abstract.
- Wilder, J.W.; Christie, I.; Colbert, J.J. 1995. Modelling of two-dimensional spatial effects on the spread of forest pests and their management. *Ecological Modelling*. 82: 287-298.
- Wilder, J.W.; Vasquez, D.A.; Christie, I.; Colbert, J.J. 1995. Wave trains in a model of gypsy moth population dynamics. *CHAOS*. 5 (4): 700-706.
- Williams, David W.; Liebhold, Andrew M. 1996. Herbivorous insects and climate change: potential changes in the spatial distribution of forest defoliator outbreaks. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program. 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 216. Abstract.
- Williams, David W.; Liebhold, Andrew M. 1995. Herbivorous insects and global change: potential changes in the spatial distribution of forest defoliator outbreaks. *Journal of Biogeography*. 22: 665-671.
- Williams, David W.; Liebhold, Andrew M. 1995. Influence of weather on the synchrony of gypsy moth (Lepidoptera: Lymantriidae) outbreaks in New England. *Environmental Entomology*. 24 (5): 987-995.
- Williams, David W.; Liebhold, Andrew M. 1995. Influence of weather on the synchrony of gypsy moth (Lepidoptera: Lymantriidae) outbreaks in New England. *Environmental Entomology*. 24 (5): 987-995.
- Willis, Raymond B.; Montgomery, Michael E.; ODell, Thomas M. 1995. Bioavailable iron: importance of amorphous compared to crystalline ferric phosphate. In: 109th AOAC international annual meeting & exposition; 1995 September 17-21; Nashville, TN. Arlington, VA: American Association of Analytical Chemists: 63-64. Abstract.
- Willis, Raymond B.; Montgomery, Michael E.; Allen, Philip R. 1996. Improved method for manual, colorimetric determination of total Kjeldahl nitrogen using salicylate. *Agricultural and Food Chemistry*. 44 (7): 1804-1807.
- Yarie, John; Hammond, Tim. 1996. Carbon balance of the Alaskan boreal forest. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program. 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214, Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 227. Abstract.
- Young, Rebecca F.; Shields, Kathleen S.; Berlyn, Graeme P. 1995. Hemlock woolly adelgid (Hemiptera: Adelgidae): stylet bundle insertion and feeding sites. *Annals of the Entomological Society of America*. 88 (6): 827-835.
- Zhou, Guofa; Liebhold, Andrew M. 1995. Forecasting gypsy moth defoliation with a geographical information system. *Entomologiae Senica*. 2 (1):

**Resource Analysis  
Research**

Alerich, Carol L. 1996. Results of the 1993 forest inventory. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 3-11.

Alerich, Carol L.; Drake, David A. 1995. Forest statistics for New York 1980 and 1993. Resour. Bull. NE-132. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 249 p.

Araman, Philip A.; West, Cynthia D. 1996. Announcing...the Hardwood Utilization Consortium. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 47. Abstract.

Araman, Philip A.; West, Cynthia D. 1996. Innovative and coordinated solutions for the hardwood industry: the hardwood utilization consortium. In: 24th annual hardwood symposium: putting research to work in the hardwood industry: new technology available today; 1996 May 8-11; Cashiers, NC. Memphis, TN: National Hardwoods Lumber Association: 6 p.

Bick, Steven; Haney, Jr., Harry L.; West, Cynthia D. 1996. Profiles of conservation easements on forest land in northern New York. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 23. Abstract.

Birch, Thomas W. 1996. Forest land parcelization and fragmentation. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 98-110.

Birch, Thomas W. 1996. Private forest landowners of the United States, 1994. Resour. Bull. NE-134. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 183 p.

Birch, Thomas W. 1996. Private forest landowners of the United States, 1994. In: Baughman, Melvin J., ed. Proceedings of symposium on nonindustrial private forests: learning from the past, prospects for the future; 1996 February 21-24; Washington, DC. St. Paul, MN: University of Minnesota, Minnesota Extension Service: 10-20.

Birch, Thomas W. 1996. Private ownership trends in New York. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 14-21.

Blatner, Keith A.; Lee, Sang-Min; Chapman, Roger C.; Hansen, Bruce. 1996. The Korean market for temperate hardwoods: a comparison of trade statistics. Northern Journal of Applied Forestry. 13 (2): 59-67.

Bohlen, Patrick J.; Pouyat, Richard V.; Eviner, Valerie; Groffman, Peter M. 1996. Short and long-term effects of earthworms on nitrous oxide fluxes in forest soils. Supplement to Bulletin of the Ecological Society of America. 77(3): 43. Abstract.

Docteur, Michelle M.; Heisler, G.M. 1996. Ultraviolet radiation in urban environments and potential effects on human health. In: Proceedings of spotlight on research '96 undergraduate and graduate research symposium: 1996 April 19; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry. Abstract.

Drake, David A. 1996. Inventory design and limitations. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 12-13.

Emanuel, David M. 1995. HDC export report. Harrisburg, PA: Pennsylvania Hardwoods Development Council. 5 p.

Engle, Catherine A. 1996. Factors influencing material substitution in the United States pallet industry. In: Dolan, J. Daniel; Riegel, Angela, eds. Proceedings, environmental issues affecting the forest products industries in the Eastern United States; 1994 August 24-26; Baltimore, MD. Gen. Tech. Rep. NE-219. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 119-121.

- Gansner, David A.; King, Susan L.; Arner, Stanford L.; Drake, David A. 1996. Mapping shifts in the relative stocking of tree species. *Northern Journal of Applied Forestry*. 13 (2): 92-95.
- Gao, Wei; Grant, Richard H.; Heisler, Gordon M. 1996. Spectral radiative properties of various tree species in ultraviolet wavelengths and irradiance modeling implications. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & aerobiology; 1996 January 28-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 417-418.
- Grant, Richard H. 1996. Characterization of UVA and UVB irradiance sensors. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & aerobiology; 1996 January 18-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 169-172.
- Grant, Richard H.; Gao, Wei; Heisler, Gordon M. 1996. The distribution of photosynthetically-active radiance and its influence on shadowband corrections under clear and translucent overcast conditions. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & aerobiology; 1996 January 28-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 157-160.
- Grimmond, C.S.B.; Oke, T.R.; Spronken-Smith, R.; Jauregui, E.; Souch, C.; Newton, T. 1996. Heat storage in urban areas. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & aerobiology; January 28-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 466-469.
- Grove, J.M.; Zipperer, W.C.; Neville, L.R. 1995. Social indicators and classification for urban ecosystem management. In: Kollin, Cheryl; Barratt, Michael, eds. *Proceedings of the 7th national urban forest conference*; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 13-16.
- Grove, Jonathan Morgan. 1996. The relationship between patterns and processes of social stratification and vegetation of an urban-rural watershed. New Haven, CT: Yale University. 109. Ph.D. dissertation.
- Hansen, Bruce G.; Worthington, Virginia; West, Cynthia D. 1996. The state of origin of U.S. hardwood log and lumber exports. In: *Forest Products Society annual meeting: abstracts*; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 47. Abstract.
- Hansen, Lance Darrick; Heisler, G.M. 1996. Computer simulation studies of tree effects on residential energy use. In: *Proceedings of spotlight on research '96 undergraduate and graduate research symposium*. 1996 April 19; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry. Abstract.
- Heisler, Gordon M.; Grant, Richard H.; Gao, Wei. 1996. UVB and PAR in the vicinity of urban trees and buildings. In: 22nd conference on agricultural & forest meteorology and 12th conference on biometeorology & aerobiology; 1996 January 28-February 2; Atlanta, GA. Boston, MA: American Meteorological Society: 460-461.
- Heisler, Gordon M.; Grant, Richard H.; Grimmond, Sue; Souch, Catherine. 1995. Urban forests-cooling our communities? In: Kollin, Cheryl; Barratt, Michael, eds. *Proceedings of the 7th national urban forest conference*; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 31-34.
- Hershey, Rachel R. 1996. Understanding the spatial distribution of tree species in Pennsylvania. In: Mowrer, H. Todd; Czaplewski, Raymond L.; Hamre, R.H.; eds. *Spatial accuracy assessment in natural resources and environmental sciences: second international symposium*; 1996 May 21-23; Fort Collins, CO. Gen. Tech. Rep. RM-277. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 73-82.
- Hershey, Rachel R.; Ramirez, Martin A.; Drake, David A. 1995. Exploring the geostatistical techniques available to create a map of tree species distribution: an example using forest inventory and analysis (FIA) data. In: Thompson, Joyce Elma, comp. *Analysis in support of ecosystem management. Analysis workshop III*; 1995 April 10-13; Fort Collins, CO. Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Analysis Center: 20-30.

Hershey, Rachel, R.; Befort, William A. 1996. An airphoto guide for New England forest cover types: a stereo key in color infrared. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 452-454.

Hershey, Rachel, R.; Birch, Thomas W. 1996. Method for identifying urban forest from forest inventory analysis (FIA) data. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 59-71.

Hodge, Sandra S.; Birch, Thomas W. Virginia NIPF landowners survey, 1991 and 1994. In: Baughman, Melvin J., ed. Proceedings of symposium on nonindustrial private forest: learning from the past, prospects for the future; 1996 February 21-24; Washington, DC. St. Paul, MN: University of Minnesota, Minnesota Extension Service: 454. Abstract.

King, Susan L. 1996. Neural networks vs. traditional techniques for forestry data. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF Publ. 96-01. Bethesda, MD: Society of American Foresters: 449-451.

King, Susan L.; Gansner, David A. 1995. Trends in relative stocking help locate forest health problems. In: Sessions, John; Brodie, J. Douglas, eds. Management systems for a global economy with global resource concerns. Proceedings of the 1994 symposium on systems analysis in forest resources; 1994 September 6-9; Pacific Grove, CA. Bethesda, MD: Society of American Foresters: 418-426.

Lawson, Penny S.; Thomas, R. Edward; Walker, Elizabeth S. 1996. Optigrami V2 Users Guide. Gen. Tech. Rep. NE-222. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 46.

Luley, Christopher J. 1995. Funding urban forestry: air pollution and carbon credits. In: Kollin, Cheryl; Barratt, Michael, eds. Proceedings of the 7th national urban forest conference; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 194-197.

Luppold, William. 1996. Regional differences in red oak lumber prices. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 43. Abstract.

Luppold, William. 1996. Structural changes in the Appalachian sawmilling industry. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 43. Abstract.

Luppold, William. 1996. The relationship between structural change and lumber price. In: Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 27. Abstract.

Luppold, William. 1996. An explanation of hardwood lumber pricing. *Forest Products Journal*. 46 (5): 52-55.

Luppold, William. 1996. Structural changes in the central Appalachian hardwood sawmilling industry. *Wood and Fiber Science*. 28 (3): 346-355.

Luppold, William G. 1995. Making utilization and marketing research serve producers and users of hardwood lumber. In: Lowery, Glenn; Meyer, Dan, eds. Advances in hardwood utilization: following profitability from the woods through rough dimension. Proceedings of the 23rd annual hardwood symposium; 1995 May 17-20; Cashiers, NC. Memphis, TN: National Hardwood Lumber Association: 1-4.

Luppold, William G. 1995. Regional differences in the eastern hardwood sawmilling industry. *Forest Products Journal*. 45 (10): 39-43.

Luppold, William G. 1996. A comparison of the Appalachian and southern hardwood sawmill industry. In: Caulfield, Jon P.; Bullard, Steven H., eds. A world of forestry: proceedings of the 25th annual southern forest economics workshop; 1995 April 15-19; New Orleans, LA. Starkville, MS: Mississippi State University, Department of Forestry: 219-227.

- McDonnell, M.J.; Pickett, S.T.A.; Pouyat, R.V.; Zipperer, W.C. 1995. Urban-rural ecological gradients: a new perspective for urban forestry. In: Kollin, Cheryl; Barratt, Michael, eds. Proceedings of the 7th national urban forest conference; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 22-24.
- McHale, P.J.; Mitchell, M.J. 1996. Disturbance effects on soil solution chemistry due to heating cable installation. *Biology and Fertility of Soils*. 22: 40-44.
- McHale, Patrick J.; Mitchell, Myron J.; Raynal, Dudley J.; Bowles, Francis P. 1996. Increasing soil temperature in a northern hardwood forest: effects on elemental dynamics and primary productivity. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 146-152.
- McWilliams, William H.; Arner, Stanford L.; Birch, Thomas W.; Widmann, Richard H. 1996. Cutting activities in New York forest. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 33-40.
- McWilliams, William H.; Arner, Stanford L.; Wharton, Eric H.; Hershey, Rachel R. 1996. Ecoregion-scale monitoring and assessment: a Pennsylvania case study. In: Sustaining forests, sustaining people: proceedings of the 1995 Society of American Foresters convention; 1995 October 28-November 1; Portland, ME. SAF publ. 96-01. Bethesda, MD: Society of American Foresters: 461-462.
- McWilliams, William H.; Stout, Susan L.; Bowersox, Todd W.; McCormick, Larry H. 1995. Adequacy of advance tree-seedling regeneration in Pennsylvania's forest. *Northern Journal of Applied Forestry*. 12 (4): 187-191.
- McWilliams, William H.; White, Robert; Arner, Stanford L.; Nowak, Christopher A.; Stout, Susan L. 1996. Characteristics of declining forest stands on the Allegheny National Forests. Res. Note NE-360. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9 p.
- Moulton, Robert J.; Birch, Thomas W. 1995. Southern private forest landowners: a profile. *Forest Farmer Magazine*. 54 (5): 44-46.
- Moulton, Robert J.; Birch, Thomas W. 1996. Western forest landowners: a profile. *National Woodlands*. July: 14-16.
- Neville, L.R.; Grove, J.M.; Zipperer, W.C. 1995. Ecological classification for urban ecosystem management. In: Killin, Cheryl; Barratt, Michael, eds. Proceedings of the 7th national urban forest conference; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 10-12.
- Nilon, Charles. 1996. Wildlife conservation issues in ecological restoration of urban areas. In: Paved to protected: restoration in the urban/rural context. Society for Ecological Restoration 1996 international conference; 1996 June 17-22; New Brunswick, NJ. Madison, WI: Society for Ecological Restoration: 79. Abstract.
- Nolley, Jean W. 1995. Bulletin of hardwood market statistics: first, second, and third quarters-1994. Res. Note NE-359. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 21 p.
- Nowak, David J. 1995. Trees pollute? a "TREE" explains it all. In: Kollin, Cheryl; Barratt, Michael, eds. Proceedings of the 7th national urban forest conference; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 28-30.
- Pouyat, R.V.; Groffman, P.M.; Carreiro, M.M.; Bohlen, P.; Parmelee, R.W. 1996. Temperature and earthworm effects on C and N dynamics in oak stands along an urban-rural land use gradient. In: Hom, John; Birdsey, Richard; O'Brian, Kelly, eds. Proceedings, 1995 meeting of the Northern Global Change Program; 1995 March 14-16; Pittsburgh, PA. Gen. Tech. Rep. NE-214. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 208. Abstract.
- Pouyat, Richard V. 1996. Review of "Urban forest landscapes-integrating multidisciplinary perspectives." *Northwest Science*. 70(2): 187-188.

Pouyat, Richard V. 1996. Urban environmental effects on terrestrial ecosystems. In: Paved to protected: restoration in the urban/rural context. Society for Ecological Restoration 1996 international conference; 1996 June 17-22; New Brunswick, NJ. Madison, WI: Society for Ecological Restoration: 84. Abstract.

Pouyat, Richard V.; Bohlen, Patrick V.; Eviner, Valerie; Carreiro, Margaret M.; Groffman, Peter M. 1996. Short and long-term effects of earthworms on N dynamics in forest soils. Supplement to Bulletin of the Ecological Society of America, 77(3): 359. Abstract.

Romig, Robert L. 1996. Characteristics of innovativeness among dimension and millwork firms in Kentucky, Ohio, Pennsylvania, and West Virginia. In Forest Products Society annual meeting: abstracts; 1996 June 23-26; Minneapolis, MN. Madison, WI: Forest Products Society: 16. Abstract.

Scheerer, Catherine Engle; Bush, Robert J.; West, Cynthia D. 1996. The use of substitute material pallets for grocery distribution. *Forest Products Journal*. 46 (2): 29-36.

Smith, Paul M.; Michael, Judd H.; West, Cynthia D. 1995. Objective-oriented strategies for international furniture market participants. *Taiwan Forest Products Journal*. 14 (1): 166-184.

Steinberg, David A. 1995. Earthworm activity and nitrogen mineralization rates along an urban-rural land use gradient. In: Undergraduate research reports: summer 1991, 1992, and 1993. Occas. Publ. 10. Millbrook, NY: Institute of Ecosystem Studies: 152-157.

West, Cynthia D.; Cooper, Juett R. 1996. Marketing and technology—do they pay? In: 24th annual hardwood symposium: putting research to work in the hardwood industry: new technology available today; 1996 May 8-11; Cashiers, NC. Memphis, TN: National Hardwoods Lumber Association: 14 p.

West, Cynthia D.; Hansen, Bruce. 1996. Forest resource issues and the sustainability of hardwood resource supplies. In: 1st annual Asian hardwood market seminar; 1996 June 7; Hong Kong. Washington, DC: American Hardwood Export Council: 16 p.

West, Cynthia D.; Hansen, Bruce. 1996. Trends in furniture consumption and industry development in Pacific Rim countries with special reference to the USA, Japan and China. In: Successful marketing through improved technology, quality & design: seminar on furniture marketing; 1996 March 8-9; Kuala Lumpur, Malaysia. Kuala Lumpur, Malaysia: Malaysian Timber Industry Board: 31 p.

Wharton, Eric H.; Mullarkey, Kevin M.; Grant, Beverly R. 1996. Timber removals in New York. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 41-58.

Widmann, Richard H. 1996. A closer look at key species. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 22-32.

Widmann, Richard H. 1996. Forest resources of New York's Capitol District. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 142-148.

Widmann, Richard H. 1996. Forest resources of New York's Catskill Lower Hudson Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 156-162.

Widmann, Richard H. 1996. Forest resources of New York's Eastern Adirondack Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 149-155.

Widmann, Richard H. 1996. Forest resources of New York's Lake Plain Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 163-169.

- Widmann, Richard H. 1996. Forest resources of New York's South-Central Highland Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 170-176.
- Widmann, Richard H. 1996. Forest resources of New York's Southwest Highland Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 184-190.
- Widmann, Richard H. 1996. Forest resources of New York's St. Lawrence/Northern Adirondack Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 177-183.
- Widmann, Richard H. 1996. Forest resources of New York's Western Adirondack Unit. In: Conference proceedings: the Empire Forest—changes and challenges; 1996 November 13-14; Syracuse, NY. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 190-197.
- Widmann, Richard H. 1996. Pulpwood production in the Northeast: 1991, 1992, and 1993. Resour. Bull. NE-133. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 24 p.
- Wildland Resources Center. 1996. Summary of the Sierra Nevada Ecosystem Project report. Wildland Resour. Cent. Rep. 39. Davis, CA: University of California, Centers for Water and Wildland Resources: 22 p.
- Zipperer, W.C.; Grove, J.M.; Neville, L.R. 1995. Ecosystem management in urban environments. In: Kollin, Cheryl; Barratt, Michael, eds. Proceedings of the 7th national urban forest conference; 1995 September 12-16; New York, NY. Washington, DC: American Forests: 6-9.
- Zipperer, Wayne C. 1996. Future research directions for managing and restoring urban woodlands. In: Paved to protected: restoration in the urban/rural context. Society for Ecological Restoration 1996 international conference; 1996 June 17-22; New Brunswick, NJ. Madison, WI: Society for Ecological Restoration: 104. Abstract.

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